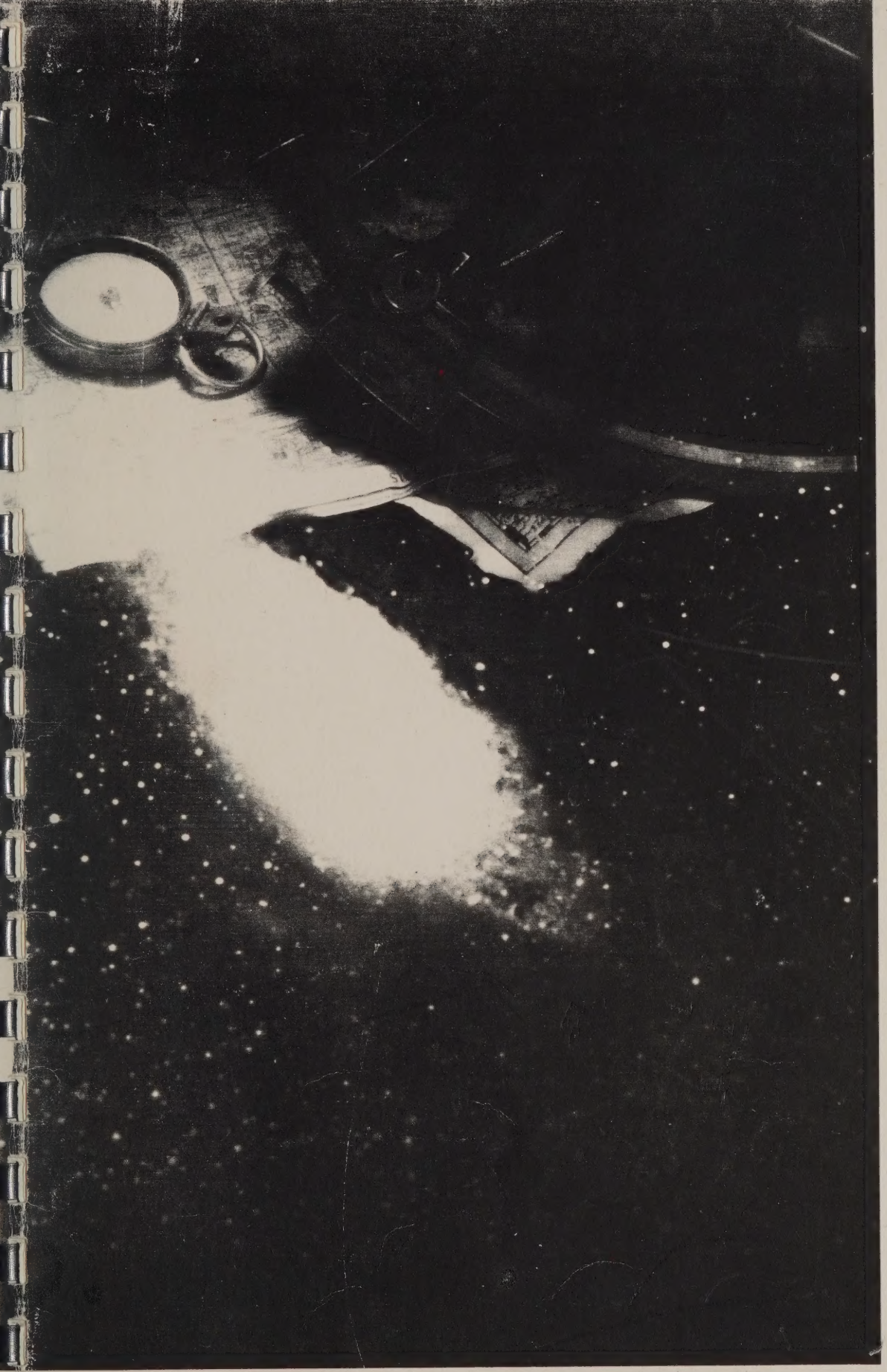

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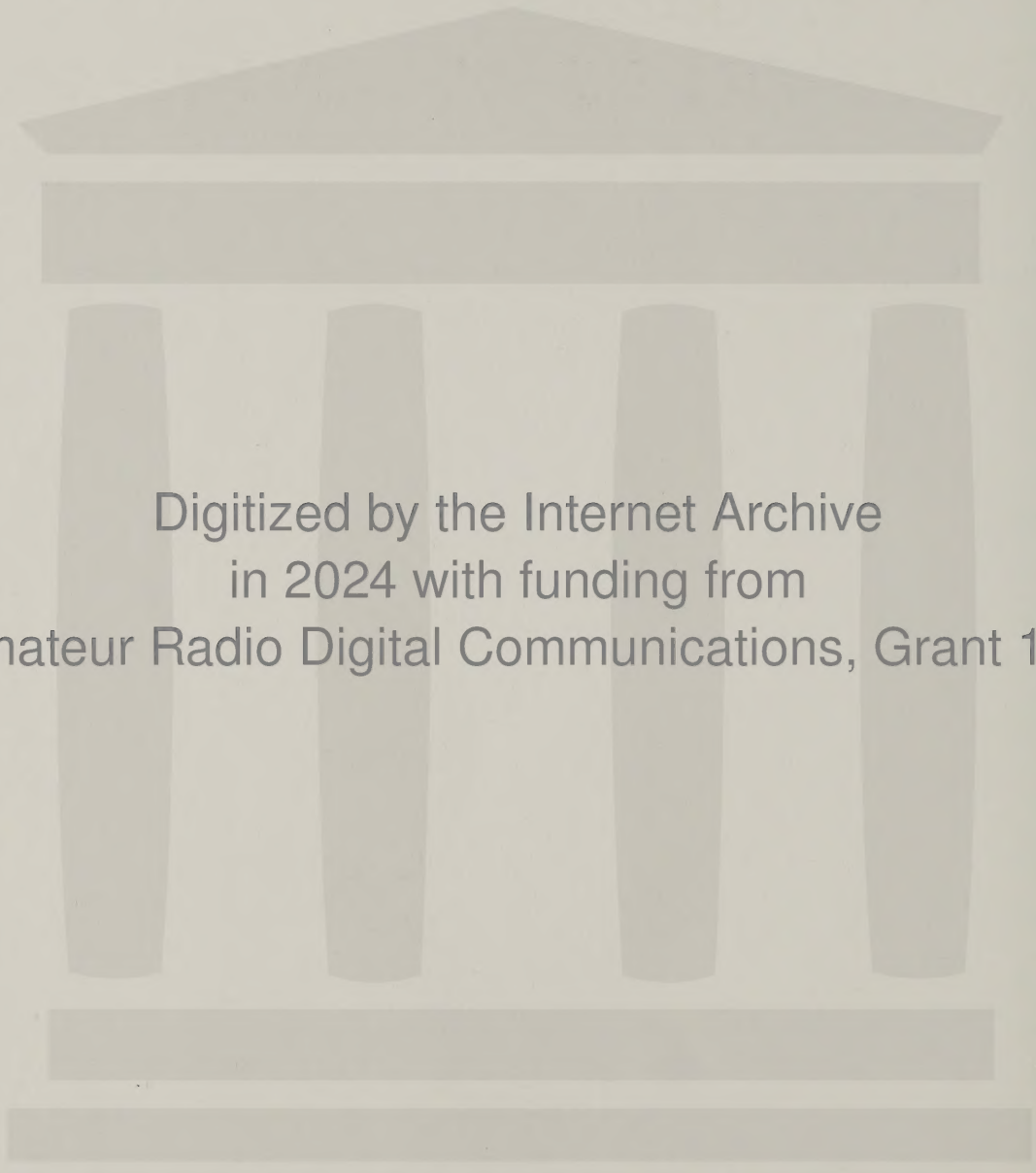

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GPS RECEIVER TECHNICAL REFERENCE MANUAL

October 1993

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68P41117U01
Revision 4.5
For Use with GPS Receiver Board Firmware Release 4.X

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GPS RECEIVER
TECHNICAL REFERENCE MANUAL

October 1990

WELCOME!

Welcome to Motorola's family of Global Positioning System (GPS) products. Your GPS product carries with it nearly a decade of Motorola GPS experience, combined with world-class expertise in semiconductor and communication technologies. Thank you for choosing Motorola.

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1-800-272-1477

ABOUT THIS MANUAL

This manual provides complete information detailing description, installation and integration of your Motorola GPS Receiver/Antenna system. To help you find the information you need, we have provided a brief overview of each chapter.

Chapter 1 General Information

A NAVigation Satellite Timing and Ranging (NAVSTAR) Global Positioning System (GPS) operating overview along with a discussion of its navigation message. Also, GPS Receiver product highlights including potential applications, options, special features, and a list of publicly available GPS information services.

Chapter 2 Product Description

Functional overviews of the GPS Receiver and its Antenna Module. Also, electrical and environmental specifications in easy-to-use tabular form.

Chapter 3 Hardware Installation

Detailed GPS hardware mounting and assembly instructions including pertinent dimensioning information. Also, electromagnetic, thermal, and electrical grounding considerations; views of Receiver Power/Data connector pin assignments; and a discussion of antenna cable/connector requirements.

Chapter 4 System Integration

A discussion of GPS Receiver operational considerations along with a complete explanation of available input/output (I/O) formats. Also, in the section printed on buff colored paper, a clear definition of all input commands with their corresponding response messages.

Appendixes

Appendix A: Glossary of GPS terms.

Appendix B: Listing of available coordinate system datums and related parameters.

Appendix C: Quick-reference listing of available input commands, with their corresponding output response messages.

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CHAPTER 1
GENERAL INFORMATION

1.1 INTRODUCTION

Nearly a decade of Global Positioning System (GPS) experience, combined with world-class expertise in semiconductor products and communication development, has led Motorola to production of a new generation of GPS receiver modules, more compact and lightweight than ever before. Each channel of this versatile, 6-channel receiver independently tracks both code and carrier phases for the superior performance required in today's GPS user environment. Time recovery and differential GPS features also are inherent in the design. Specifically designed for embedded applications, the GPS Receiver, when combined with its new, low-profile, active microstrip patch antenna, affords the engineer new freedom in bringing GPS technology to the most demanding Original Equipment Manufacturer (OEM) applications.

The Motorola GPS Receiver transmits autonomous position, velocity, heading, satellite tracking status, and time information in three different, user-selectable I/O protocols: Motorola Binary Format; National Marine Electronics Association (NMEA)-0183 Format; LORAN Emulation Format. In addition, the basic GPS Receiver may be configured to include 1PPS (1 pulse per second) timing output, real-time differential GPS capabilities (both master and remote stations), and raw pseudorange/carrier phase observation data output.

1.2 NAVSTAR GPS

1.2.1 Overview. The NAVigation Satellite Timing and Ranging (NAVSTAR) GPS is an all-weather, radio based, satellite navigation system that enables users to accurately determine 3-dimensional position, velocity, and time. The overall system (Figure 1-1) consists of three major segments: the space segment, the ground control segment, and the user segment.

The space segment is a constellation of satellites operating in 12-hour orbits at an altitude of 20,183 km (10,898 nmi). When completed, this constellation will contain 21 satellites (plus three spares) in six orbits, each orbital plane equally spaced about the equator and inclined at 55 degrees.

The ground control segment consists of a master control center and a number of widely separated monitoring stations. The ground control network tracks the satellites, precisely determines their orbits, and periodically uploads ephemeris correction and other system data to all satellites for retransmission to the user segment.

The user segment is the collection of all GPS user receivers (such as your Motorola GPS Receiver) and their support equipment. Navigation with the receiver is accomplished by passive multi-lateration. More simply, the GPS Receiver's position is determined by the geometric intersection of several simultaneously observed ranges (satellite to receiver distances) from satellites with known coordinates in space. The receiver measures the transmission time required for a satellite signal to reach the receiver. Transit time is determined

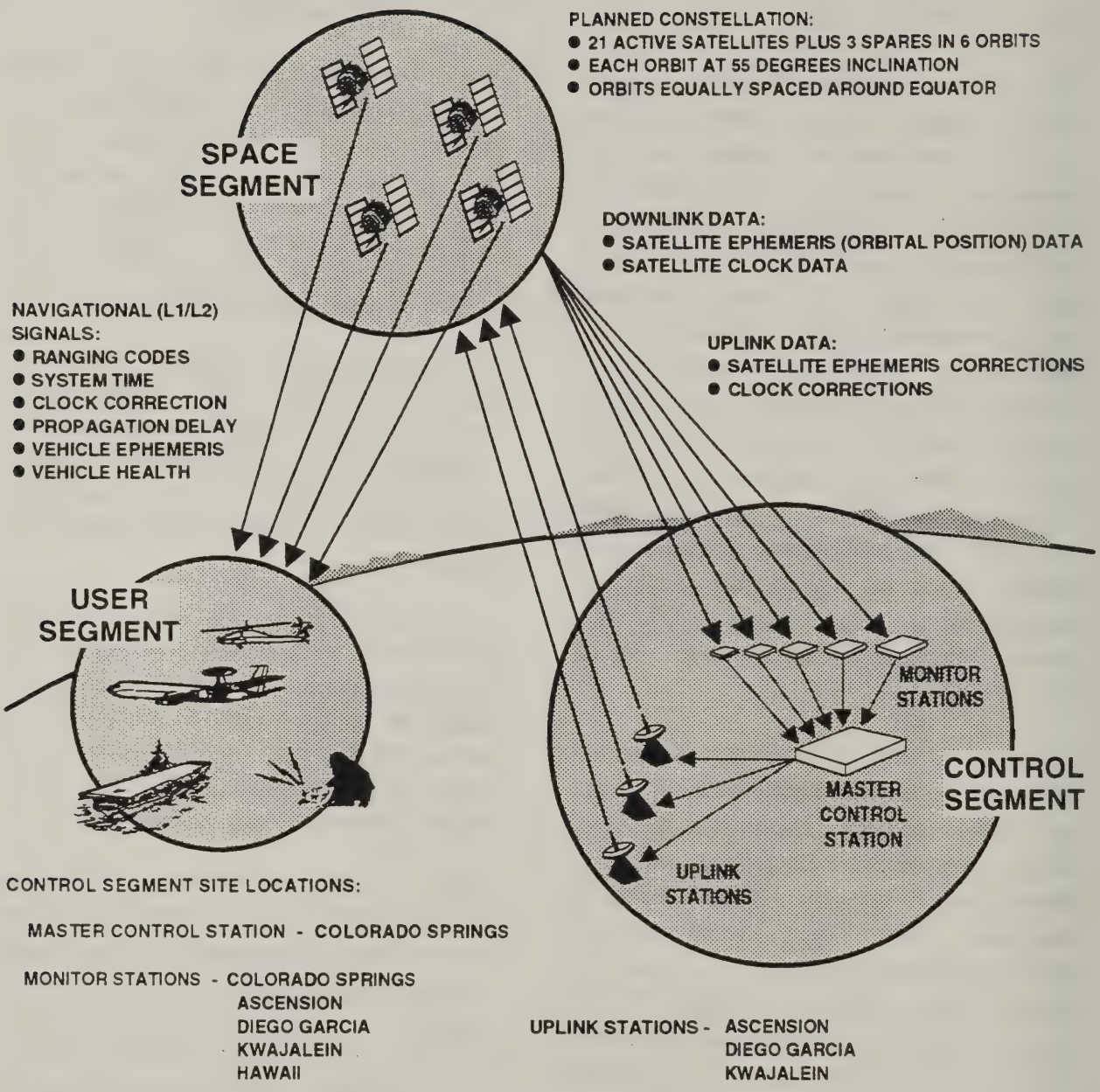

Figure 1-1. NAVSTAR GPS System

using code correlation techniques. The actual measurement is a unique time shift for which the code sequence transmitted by the satellite correlates with an identical code generated in the tracking receiver. The receiver code is shifted until maximum correlation between the two codes is achieved. This time shift multiplied by the speed of light is the receiver's measure of the range to the satellite. Because this measurement includes various propagation delays, as well as satellite and receiver clock errors, it is not a true geometric range and so is called a pseudorange. The receiver processes these pseudorange measurements along with the received ephemeris data (satellite orbit data) to determine the user's three-dimensional position. A minimum of four pseudorange observations are required to mathematically solve for four unknown receiver parameters (i.e., latitude, longitude, altitude, time). If one of these parameters is known (for example, altitude fixed) then only three satellite pseudorange observations are required and thus only three satellites need to be tracked in these cases.

1.2.2 The GPS Navigation Message. The GPS navigation message is the data supplied to the user from a satellite. Signals are transmitted at two L-band frequencies, L1 and L2, to permit corrections to be made for ionospheric delays in signal propagation time.

The L1 carrier is modulated with a 10.23 MHz precision ranging (P-code) signal and a 1.023 MHz clear acquisition (C/A code) ranging signal. These are pseudo random (PR) noise codes in phase quadrature. The L2 signal is modulated with the P-code only. Both the L1 and L2 signals also are continuously modulated with a data-bit stream at 50 bits per second. The P-code is a PR sequence with a period of 38(+) weeks. The C/A code is a shorter PR sequence of 1023 bits having a period of one millisecond. The P-codes intended for military use and ultimately will be available to authorized users only. Access to the GPS system by civilian users is provided through the C/A coded signals.

The navigation message consists of a 50 bit per second data stream containing information enabling the receiver to perform the computations required for successful navigation. Each satellite has its own unique C/A code that provides satellite identification for acquisition and tracking by the user.

1.2.3 Public GPS Information Services. There are several sources from which to obtain further information about GPS and the current status of the satellites. Information about four public GPS Information Centers is provided below.

USCG GPS IC
Commanding Officer (GPSIC)
Omega Navigation System Center
7323 Telegraph Rd.
Alexandria, VA 22310-3998

The Civil GPS Service was established to provide civil GPS users with information on system status and a point of contact. As a part of this service, the U.S. Coast Guard has begun operations of the GPSIC on a test and evaluation basis. Current services include GPS operational advisory broadcasts (OAB) containing current constellation status, future scheduled outages, and an almanac suitable for making GPS coverage and satellite visibility predictions. The OABs are available 24 hours a day by computer bulletin board, or as a recorded telephone message at (703) 313-5907 (without almanac). The comm

parameters for the bulletin board are: 8 data bits, 1 stop bit, no parity. For modem speeds of:

300 to 14,400 bps (705) 313-5910

For internet access, or to speak with a representative, call (703) 313-5900 or fax (703) 313-5920.

GPS Bulletin Board at Holloman

Formerly located at Yuma, Arizona, this bulletin board recently has been moved to Holloman Air Force Base. The bulletin board provides a daily almanac, observed range errors, comments on the satellite, and the OCS advisories. Requires full duplex, 8-bit data words, no parity and 1 stop bit (preferred because it supports the X-modem and Y-modem error checking block transmission) or full duplex, 7-bit word, odd or even parity, and 1 stop bit.

1200 (preferred) or 300 baud	(505) 679-1525, 1526, 1527, 1528

To speak with a representative, call (505) 679-1784, 1787, 1657

GPS Satellite Clock Behavior and Related GPS Information
U.S. Naval Observatory
Washington D.C. 20392-5100 USA

USNO Series 4 Weekly Bulletins: Received by mail, they contain information on the status of GPS and timing data.

To speak with a representative, call (202) 653-1525

Available telephone lines	(202) 653-0068, 0155, 1079
Baud rates	1200, 2400 or 9600
Comm parameters	8 data bits, 1 stop, no parity; terminate lines with CR/LF
Password	Call for password
Internet access (telnet)	tycho.usno.navy.mil (192.5.41.239) Login as ads

Comments to: adsmgr@tycho.usno.navy.mil

NOAA
National Geodetic Survey, N/CG174
SSMC 3, Station 09535
1315 E. West Highway
Silver Springs, MD 20910

Precise orbital positions and velocities based on post computations of tracking data collected from stations of the Cooperative International GPS Tracking Network (CIGNET) are available from NGS. Satellite orbital data are scheduled to be available two weeks after the tracking data are collected. For a description of formats, fee schedule, or to order data contact (301) 713-3242.

Valid characters consist of the printable ASCII characters hex 20 through hex 7F. For detailed information about NMEA formats and specifications, contact:

NMEA – National Marine Electronics Association
P. O. Box 50040
Mobile, AL 36606
(205) 473-1793

For detailed information about RTCM formats and specifications, contact:

Radio Technical Commission for Maritime Services
Post Office Box 19087
Washington, D.C. 20036

1.3 PRODUCT HIGHLIGHTS

1.3.1 Applications. Considering that 24-hour, worldwide coverage is fundamental to GPS positioning and navigation, it is easy to envision a broad range of applications and a large community of GPS users. Applications include:

- Automobile Navigation
- Aircraft Navigation
- Land Navigation
- Marine Navigation
- Fleet Tracking
- Differential Systems
- Routing Systems
- Rail Management
- Asset Management
- Emergency Search and Rescue
- Utility Services
- Precise Time Measurement
- Surveying and Mapping
- Exploration

1.3.2 Options. The following options are available for specialized applications:

- Option A
  1 Pulse Per Second (1 PPS) Output
- Option B
  Real-Time Differential (RTD) GPS Capabilities
- Options C, D, and E
  Satellite Pseudorange/Carrier Phase Data

1.3.3 Features. Features unique to the GPS Receiver/Antenna system include the following:

- 6-channel parallel receiver
- Code plus carrier tracking (carrier-aided tracking)
- Forty-nine available coordinate datums; two user-defined datums
- Selectable idle mode of operation
- Weather-resistant microstrip patch antenna
- Operates from +5 Vdc regulated or +12 Vdc unregulated (internal +5V regulator conforms to Automotive Specification SAE J113)
- RS-232C interface to host equipment
- NMEA and LORAN emulation interface capabilities
- 3-dimensional positioning within 25 meters, SEP (without selective availability [SA])
- Latitude, longitude, height, velocity, heading, time, and satellite status information output either continuously (once per second) or polled
- RTCM interface capability
- Optional real-time-differential (RTD) GPS capabilities
- Optional 1 PPS output for special time applications
- Optional satellite pseudorange/carrier phase data output

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CHAPTER 2
PRODUCT DESCRIPTION

2.1 GPS RECEIVER MODULE

2.1.1 Function Overview. The Motorola GPS Receiver Module provides position, velocity, time, and satellite tracking status.

A simplified block diagram of the GPS Receiver Module is shown in Figure 2-1.

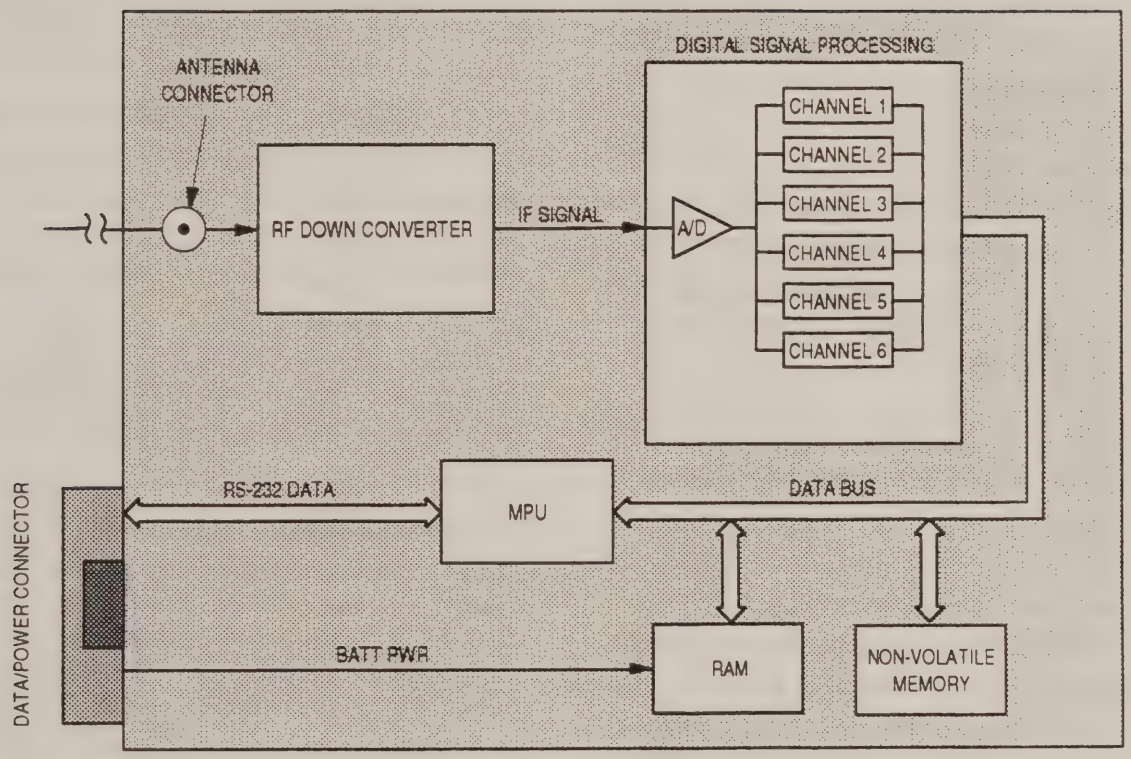

Figure 2-1. GPS Receiver Module Functional Block Diagram

The GPS Receiver Module is a 6-channel parallel design capable of tracking six satellites simultaneously. The module receives the L1 GPS signal (1575.42 MHz) and operates off the clear/acquisition (C/A) carrier tracking. The code tracking is carrier aided. The GPS Module can be powered with unregulated 12 Vdc or optionally with regulated 5 Vdc power. Differential GPS and time recovery capabilities are inherent in the architecture, and available as options.

The L1 band signals transmitted from GPS satellites are collected by a low-profile, micro-strip patch antenna, passed through a narrow band bandpass filter, and then amplified by a signal preamplifier contained within the Antenna Module. Filtered and amplified L1 band signals from the Antenna Module are then routed to the RF signal processing section of the GPS Receiver Module via a single coaxial interconnecting cable. This interconnecting cable also provides the required +5V for signal preamplification in the Antenna Module.

The RF signal processing section of the GPS Receiver printed circuit board (PCB) contains the required circuitry for downconverting the GPS signals received from the Antenna Module. The resulting intermediate frequency (IF) signal is then passed to the 6-channel code and carrier correlator section of the GPS Receiver PCB where a single, high-speed analog-to-digital (AD) converter converts the IF signal to a digital sequence prior to channel separation. This digitized IF signal is then routed to the digital signal processor (also contained within the 6-channel code and carrier correlator section) where the signal is split into six separate channels for code correlation, filtering, carrier tracking, code tracking, and signal detection.

The processed signals are synchronously routed to the position processor (microprocessor [MPU]) section. This section controls the GPS Receiver PCB operating modes and decodes and processes satellite data and pseudorange and delta range measurements used to compute position and velocity. In addition, the position processor section contains the required interface to the RS232 port used for full-duplex, asynchronous data communication with the host equipment.

Keep-alive random access memory (RAM) is provided for retention of satellite ephemeris data. To prevent loss of this information when the GPS Receiver Module is powered off, an external +12V/+5V BATT signal is required. Nonvolatile electrically erasable programmable read only memory (EEPROM) is used for storage of custom operating parameters, almanac information, and other information, as specified in Chapter 4.

Retention of the real-time-clock (RTC) value also requires the external +12V/+5V BATT signal when the GPS Receiver Module is powered off.

2.1.2 Performance Information. The GPS Receiver will meet or exceed all of the following electrical and environmental specifications (shown in Table 2-1) if operated in a dynamic environment of less than 515 meters/second (1000 nautical miles/hour) velocity, less than 2g acceleration, and less than 5 meters/second^3 jerk and will maintain lock on satellites up to 4g acceleration and 20 meters/second^3 jerk.

The GPS Receiver is capable of providing better than 25 meter position accuracy and 0.1 meter/second velocity accuracy when operated autonomously without selective/availability (S/A) and geometric dilution of precision (GDOP) is less

than 4.0. The 1 PPS (when optionally installed) has a 1 sigma accuracy of ±75 nanoseconds plus a resolution of ±52 nanoseconds.

The GPS Receiver complies with the Class B limits of FCC Part 15, Subpart B, for Unintentional Radiators and with the electromagnetic interference/electromagnetic compatibility (EMI/EMC) requirements of MIL-STD-461C, Class A1b.

2.2 ANTENNA MODULE

2.2.1 Description. The Antenna Module is housed in a custom styled, molded encasement that provides a rugged, durable protective cover, ready for exposure to the elements.

All of the Antenna Module's electrical circuitry and components are contained within the sealed antenna assembly. The major components include a low profile, microstrip patch antenna; a ceramic RF filter (i.e., preselector); and a signal preamplifier. The Antenna Module is designed and tuned to efficiently collect L1 band signals transmitted from GPS satellites at a nominal frequency of 1575.42 MHz. Once collected, the signal is amplified and relayed to the GPS Receiver Module. Signal preamplification within the Antenna Module is made possible by external power supplied by the GPS Receiver Module. The Antenna Module draws 22 mA of current (nominal), 25 mA (maximum), at 5 Vdc.

Various Antenna Module mounting options and assembly instructions are detailed in Chapter 3, Hardware Installation.

2.2.2 Antenna Gain Pattern. The ability of an antenna to successfully receive weak signals is represented by the gain of an antenna. Antenna gain varies as a function of the direction of incoming signal; some directions are much more appropriate for signal reception than others. Because of this, the gain characteristics of an antenna play a significant role in the antenna's overall performance.

A cross-sectional view of the antenna gain pattern along a fixed azimuth (in a vertical cut) is displayed in Figure 2-2. The gain pattern clearly indicates that the antenna is designed for full, upper hemispherical coverage with the gain diminishing at low elevations. This cross-section is representative of any vertical, cross-section over a 0 to 360 degree azimuth range and thus, the 3-dimensional gain pattern is a symmetric spheroidal surface. It is important to note that this gain pattern varies in elevation angle, but not in horizontal azimuth. This design is well-suited for many GPS applications, accommodating full sky coverage above the local horizon and alleviating ground-reflected multipath effects

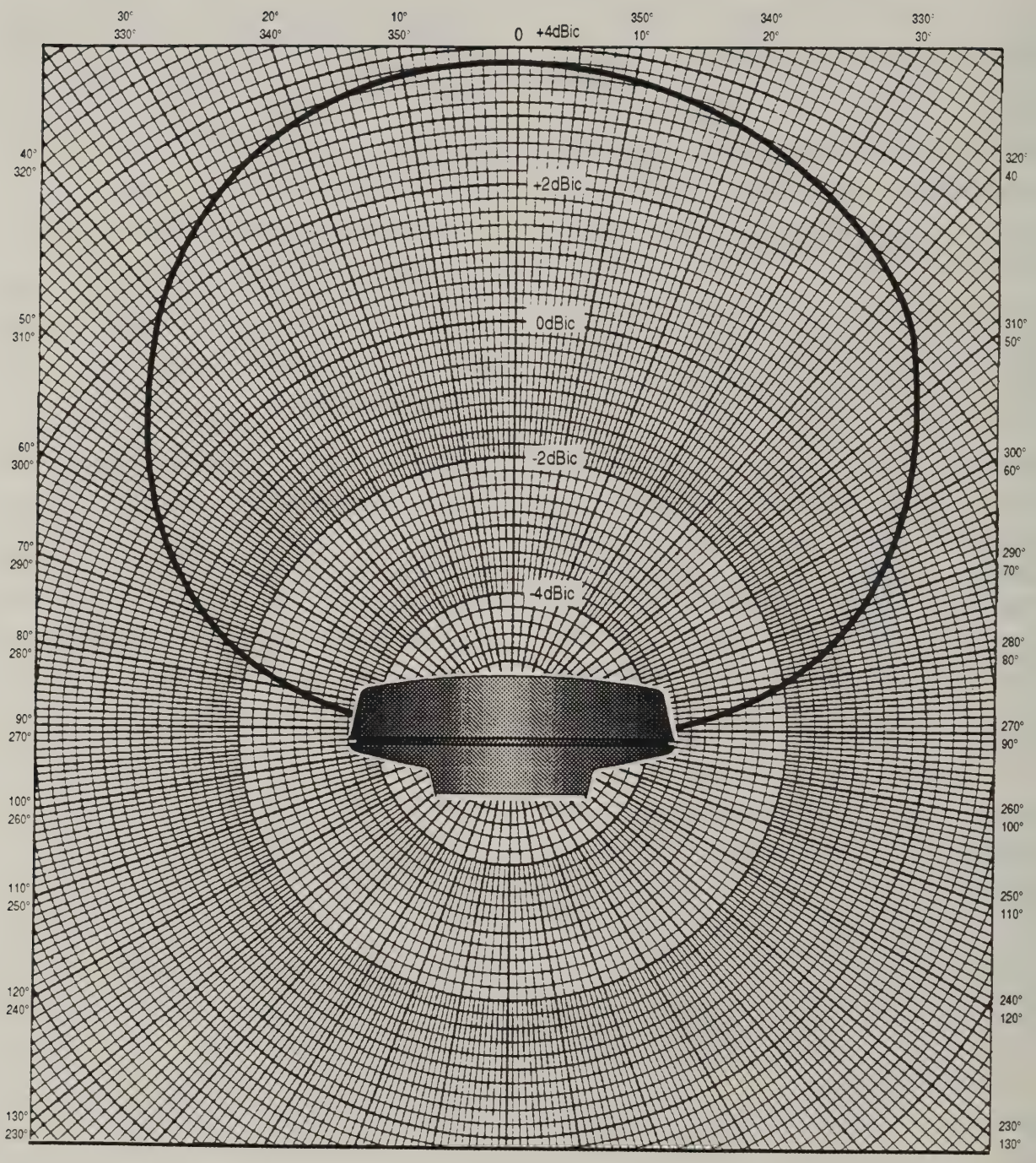

Figure 2-2. Antenna Gain Pattern

2.3 PRODUCT SPECIFICATIONS

Table 2-1. Product Specifications

Parameter	Description
Dynamics	• Velocity 1000 Knots (514.4 m/sec) • Acceleration 4 g • Jerk $5m/s^3$
Antenna	• Active microstrip patch Antenna Module • Powered by Receiver Module (5 Vdc @ 25 mA)
Antenna to Receiver Interconnection	• Single coaxial cable (6dB max loss at L1; 1575.42 MHz) • Typical length with RG58 coaxial cable; 20 feet (6 meters)
Serial Output	• RS232C Interface
Accuracy	• Less than 25 meters, SEP (without SA) *DoD may invoke Selective Availability (SA), potentially degrading accuracy to 100 meters (2d RMS)
Altitude	• 60,000 feet (18 Km) (maximum)
Operating Temperature	• Active Antenna -40°C to +100°C (–40°F to +212°F) • Receiver Module -30°C to +80°C (-22°F to 176°F)
Humidity	• 95% non-condensing +30°C to +60°C (+86°F to +140°F)
Physical Dimensions	• Receiver PCB 3.94 X 2.76 X 0.65 in (100 X 70 X 16.5 mm) • Antenna Module 4.01 (dia) X 0.89 in (102 (dia) X 22.6 mm)
Weight	• Receiver and Housing 4.5 oz (128 g) • Antenna Module 4.8 oz (136.2 g)
Switched Power	• 9 to 16 Vdc or • 5 ± 0.25 Vdc
"Keep-Alive" BATT Power	• 4.75 – 16 Vdc; 0.3 mA
Power Consumption (typical)	• 1.3 W @ 5 Vdc input • 1.8 W @ 12 Vdc input
Receiver Interconnection	• AMP 10 pin, #104369-4 on Receiver Module - RS232C - Power input • OSX connector on Receiver and Antenna
MTBF (Mean Time Before Failure)	• 55,000 hours (estimated)

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CHAPTER 3
HARDWARE INSTALLATION

3.1 RECEIVER MODULE INSTALLATION

Your GPS Receiver has been carefully inspected and packaged to ensure optimum performance. As with any piece of electronic equipment, proper installation is essential before you can use the equipment.

You can mount the GPS Receiver into your existing system in its plastic housing or you can remove it from the housing and mount it.

3.1.1 Installer Beware! Before you install the GPS Receiver, please review the following precautions and considerations.

3.1.1.1 Electrostatic Precautions. The GPS Receiver PCB contains parts and assemblies sensitive to damage by electrostatic discharge (ESD). Use ESD precautionary procedures when handling the printed circuit board.

3.1.1.2 Electromagnetic Considerations. The GPS Receiver PCB contains a very sensitive RF receiver; you must observe certain precautions to prevent possible interference from the host system. Because the electromagnetic environment will vary for each OEM application, it is not possible to define exact guidelines to assure electromagnetic compatibility.

In worst-case situations, the GPS Receiver PCB may require enclosure in a metal shield to eliminate any electromagnetic compatibility (EMC) problems.

3.1.1.3 Thermal Considerations. Operating range is –30°C to +80°C; storage temperature is –40°C to +125°C. Before installation, you should perform a thermal analysis to ensure temperatures do not exceed +80° C when operating (+125° C stored) if:

- Air circulation in the installation site is poor
- Other electronics are installed in the enclosure with the GPS Receiver PCB
- The GPS Receiver PCB is enclosed within a shielded container due to electromagnetic interference (EMI) requirements

3.1.1.4 Grounding Considerations. The GPS Receiver is grounded through Pin 3 of the power/data connector. The four mounting holes in the receiver PCB are isolated from the PCB ground plane.

When installing into an existing system, ensure Pin 3 of the power/data connector has a "good ground" connection.

3.1.2 Electrical Connections. The GPS Receiver Module receives electrical power and receives/transmits ASCII signals through a 10-pin rectangular connector (power/data connector) mounted on the GPS Receiver PCB. Table 3-1 lists assigned signal connections of this power/data connector which coincides with the power/data connector pin number convention diagram in Figure 3-1.

Table 3-1. Power/Data Connector Pin Assignments[1]

Pin Number	Signal Name	Description
1	+12V/+5V BATT	(Optional) +5 Vdc regulated or +12 Vdc unregulated for running Real Time Clock and retention of satellite ephemeris information stored in keep-alive RAM memory
2	+5V MAIN	(Optional) +5 Vdc regulated for power requirements of entire GPS Receiver (+12 Vdc signal not used)
3	+12V/+5V RTN	Power supply (+5V or +12V) return
4	Vpp[2]	Flash memory (EPROM) programming voltage
5	+12V MAIN	+12 Vdc unregulated for power requirements of entire GPS Receiver
6	1 PPS[3]	(Option A) 1 pulse per second output
7	1 PPS RTN	(Option A) 1 pulse per second return
8	RS232 TXD	Serial RS232 data output
9	RS232 RXD	Serial RS232 data input
10	RS232 RTN	Signal return for RS232 signals

[1]AMP connector PN 104369-4 (installed PCB); PN 103681-2 (mating)

[2]Not used (used only by Motorola for updating of software)

[3]1 Hz pulse train with rising edge coincident with UTC/GPS 1 second tick

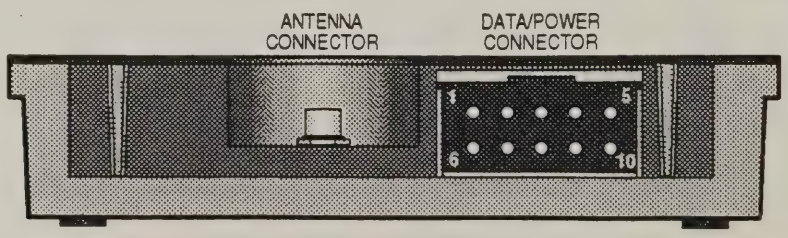


Figure 3-1. Power/Data Connector Pin Number Convention

3.1.3 Printed Circuit Board Mounting. Your GPS Receiver Module is enclosed in a plastic housing to prevent inadvertent damage and to provide environmental protection. Depending on your particular OEM application, you may install the GPS Receiver Module as shown in Figure 3-2, or you may remove the internal PCB and install it as shown in Figure 3-3 and Figure 3-4.

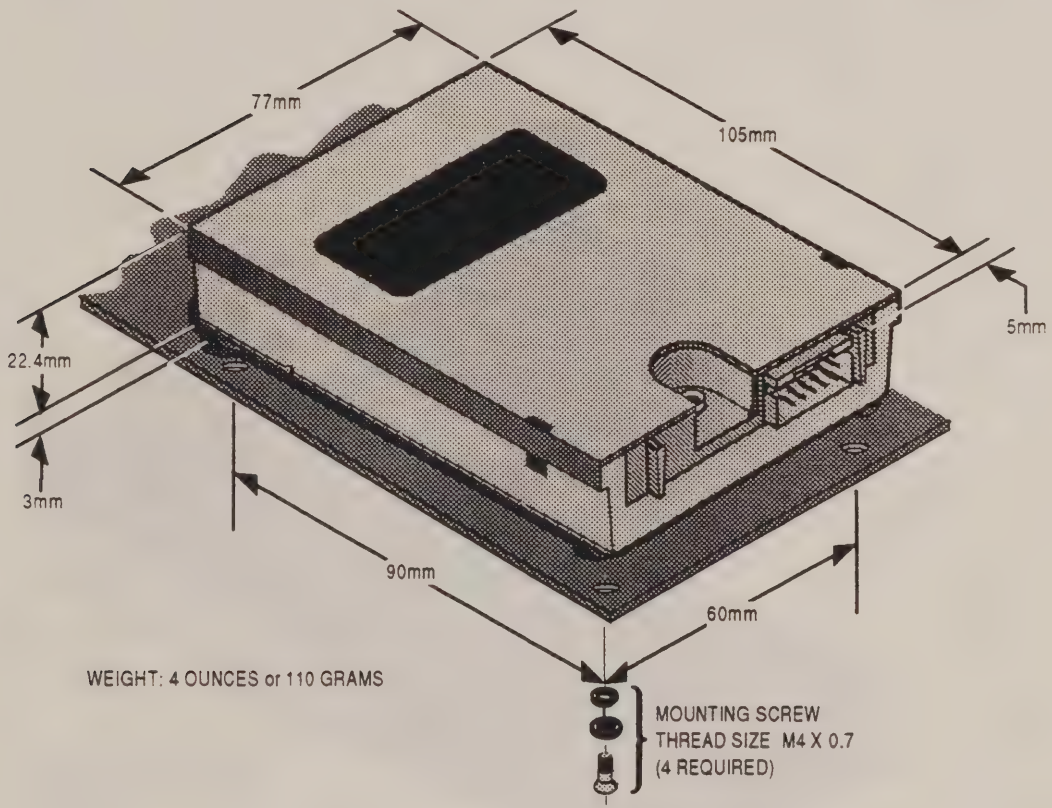


Figure 3-2. GPS Receiver Module Mounting

CAUTION: The GPS Receiver PCB contains parts and assemblies sensitive to damage by electrostatic discharge (ESD). Use ESD precautionary procedures when handling, removing or inserting the PCB.

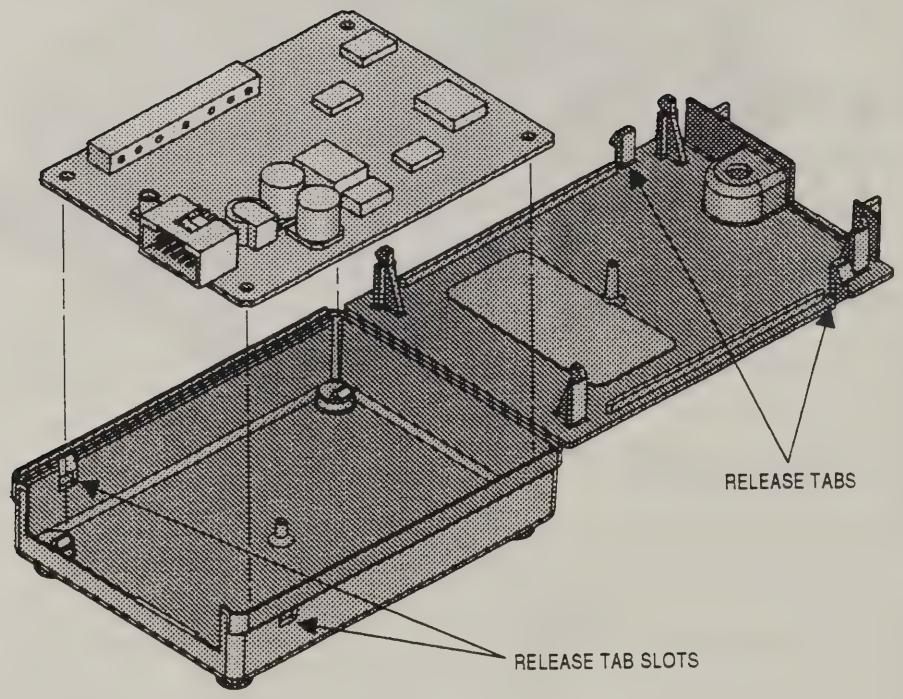


Figure 3-3. Removal of GPS Receiver PCB from Protective Housing

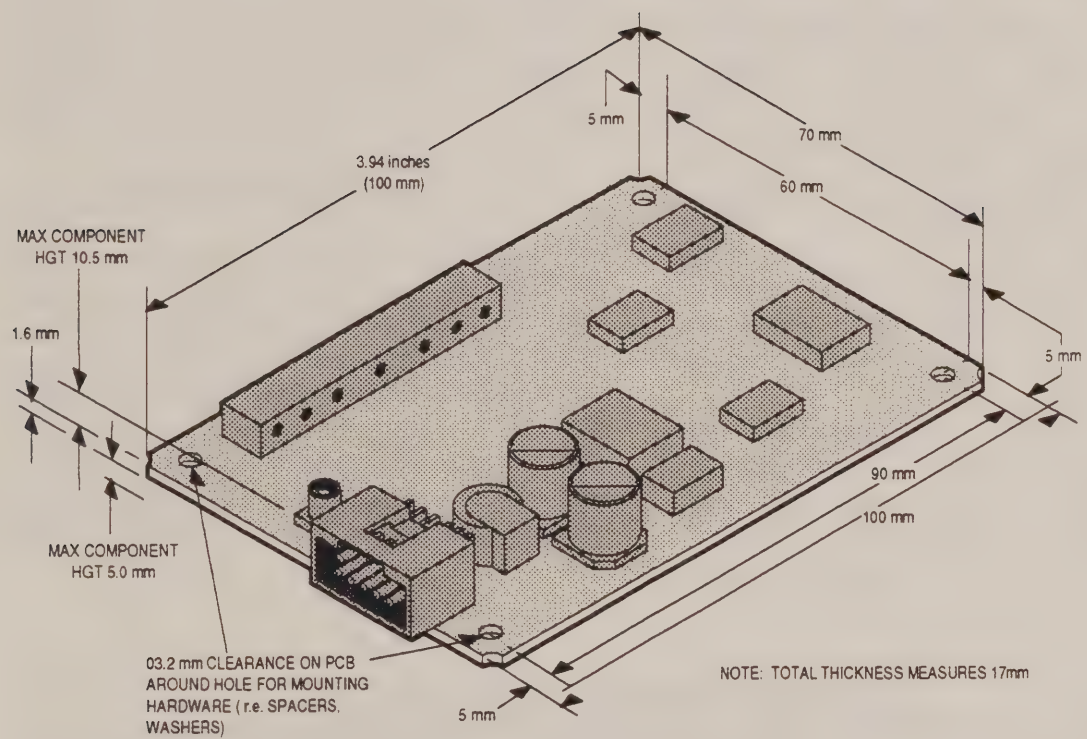


Figure 3-4. Mounting of GPS Receiver PCB

3.2 ANTENNA MODULE

Your Antenna Module contains a low-profile antenna specifically designed for GPS use. GPS signals are received by the antenna, amplified within the antenna assembly, and then relayed to the GPS Receiver Module for processing. A protective housing shields the antenna from wind, rain, and snow. Refer to Appendix D for antenna specifications and installation procedures.

CHAPTER 4
SYSTEM INTEGRATION

4.1 INTRODUCTION

The Motorola GPS Receiver is an intelligent GPS sensor intended to be used as a component in a precision navigation system. The GPS Receiver is capable of providing autonomous position, velocity, and time information over a serial RS232 port. The minimum usable system combines the GPS Receiver and an intelligent system controller device.

4.2 INTERFACE PROTOCOL

4.2.1 Overview. The Motorola GPS Receiver is provided with one RS232 serial data port. The port is configured as a data communications equipment (DCE) port and provides the main control and data path between the GPS Receiver and the system controller. The user can customize the I/O protocol on the RS-232 port to be one of three different formats. In order to support differential applications, the PVT6 GPS receiver supports various degrees of differential capabilities dependent on the selected protocol. Table 4-1 below summarizes the built-in DGPS features as a function of the user-selected I/O protocol.

Once you select a format type, the GPS Receiver operates in the selected protocol. The GPS Receiver remembers the protocol when the power is removed and initializes itself to the previous state when power is reapplied. You can switch to an alternate I/O protocol by issuing the valid "Switch Format" input command in the currently selected format. All parameters set in one format are remembered and applied in the alternate format.

The I/O port operates under interrupt control. Incoming data is stored in a buffer that is serviced by the GPS Receiver's operating program. In the Position Fix mode, this buffer is serviced every 1.0 seconds.

Table 4-1. Available Interface Protocols

FORMAT	TYPE	BAUD	BITS	START/ STOP	PARITY	FEATURES	DIFFERENTIAL CAPABILITY
Motorola	Binary	9600	8	1/1	No	Full Control/All Data	RTCM SC-104[1] and Custom[2]
NMEA-0183	ASCII	4800	8	1/1	No	Partial Control/ Selected Messages	RTCM SC-104[1]
LORAN Emulation	ASCII	1200	8	1/1	No	Little Control/ 1 Output Message	None

Notes: 1. RTCM SC-104 decoding of Message Type #1 exists in de-optioned units. It is available to all users at no additional cost.
2. The custom differential capability is available as Option-B only.

4.2.2 Motorola Binary Format Description. The binary data messages used by the GPS Receiver consist of a variable number of binary characters. These binary messages begin with the ASCII @@ characters and are terminated with the ASCII carriage return and line feed <CR><LF>. The first two bytes after the @@ characters are two ASCII message ID bytes that identify the particular structure and format of the remaining binary data. The last three bytes of all messages contain a single byte checksum (the exclusive-or of all message bytes after the @@ and before the checksum), and a message terminating ASCII carriage return line feed character sequence.

Message Start:

@@ - (two hex 40s) denotes start of binary message.

Message ID:

(A..Z)(a..z, A..Z, 0..9) - ASCII uppercase letter, followed by an ASCII lowercase or upper case letter, or digit. These two characters identify the message type, and implies the correct message length and format.

Binary Data Sequence:

Variable number of bytes of binary data dependent on the command type.

Checksum:

C - The exclusive-or of all bytes after the @@ and prior to the checksum.

Message Terminator:

<CR><LF> - carriage return line feed denoting end of the binary message.

Every GPS Receiver input command has a corresponding response message so you can verify that the input commands have been accepted or rejected by the GPS Receiver. The message format descriptions in Chapter 4 detail the input command and response message formats. Information contained in the data fields normally is numeric. The interface design assumes that the operator display is under control of an external system data processor and that display format and text messages reside in its memory. This approach gives you complete control of display format and language. The GPS Receiver reads the input command string on the input buffer once per second. If a full command has been received, then it operates on that command and performs the indicated function. The following logic relates to the input character string checks that are performed on the input commands:

- A binary message is considered to be received if:

  (1) It began with @@ and is terminated with a carriage return line feed

  (2) The message is the correct length for its type

  (3) The checksum validates

You must take care in correctly formatting the input command. Pay particular attention to the number of parameters and their valid range. An invalid message could be interpreted as a valid unintended message. A beginning @@, a valid checksum, a terminating carriage return line feed, the correct message length and valid parameter ranges are the only indicators of a valid input command to the GPS Receiver. For multiparameter input commands, the GPS Receiver will reject the entire command if one of the input parameters is out of range.

- Input and output data fields contain binary data that can be interpreted as scaled floating point or integer data. The field width and appropriate scale factors for each parameter are described in the individual I/O message format descriptions. Polarity of the data (positive or negative) is described via two's complement presentation.
- Once the input command is detected, the GPS Receiver validates the message by checking the checksum byte in the message.
- Input command messages can be stacked into the GPS Receiver input buffer, up to the depth of the message buffer (2048 characters long). The GPS Receiver will operate on all full messages received during the previous 1 second interval and will process them in the order they are received.
- Every input command has a corresponding output response message. This enables you to verify that the GPS Receiver accepted the input command. The GPS Receiver response message to properly formatted commands with at least one out-of-range parameter is to return the original nonchanged value of the parameter(s).
- Input commands may be of the type that change a particular configuration parameter of the GPS Receiver. Examples of these input command types include commands to change the initial position, the GPS Receiver internal time and date, satellite mask angle, satellite almanac, etc. These input commands, when received by the GPS Receiver, change the indicated parameter and result in a response message to show the new value of the particular parameter. If the new value shows no change, then the input command was either formatted improperly, or the parameter was out of its valid range.
- Input commands may be of the type that enable or disable the output of data or status messages. These output status messages include those that the external controller will use for measuring position, velocity, time, pseudorange, and satellite ephemeris data. Status messages are output at the selected update rate (typically, once per second) for those messages that contain position, velocity, time, or range data, or can be commanded to output the data one time upon request. Those messages that include slowly changing data, such as satellite ephemeris data, satellite visibility tables, xDOP tables, etc., are output once when the GPS Receiver detects a change in the data from the previous output data. For example, if the user enables the GPS Receiver to output ephemeris data, the GPS Receiver will output the ephemeris data once upon receipt of the input command, and then once upon detection of the change of the ephemeris (typically once per hour).

All of the Position/Status/Data message types can be selected independently to be output in a continuous fashion (at the selected update rate), or once each time the data is requested (polled). The rate at which the data is output in the continuous output mode is dependent on the type of data in the message. Table 4-2 shows the rates at which the data messages are output for each type of message, depending on the setting of the continuous/one-time option that is part of the input command.

Table 4-2. Data Message Output Rates

OUTPUT MESSAGE TYPE	CONTINUOUS (m=1...255)	ONE TIME (m=0)
Position/Channel Status	At selected update rate	When requested
Satellite Range Data Output*	At selected update rate	When requested
Pseudorange Correction Output*	At selected update rate	When requested
Ephemeris Data Output	When Eph data changes	When requested
Visible Satellite Status	When Vis data changes	When requested
DOP Table Status	When DOP data changes	When requested
Almanac Status	When Alm status changes	When requested
Almanac Data Output	When Alm data changes	When requested
Leap Second Pending		When Requested

*These output messages are available only as an option.

For the case where more than one output message is scheduled during the same 1 second interval, the GPS Receiver will output all scheduled messages, but will limit the number of bytes transmitted each second to 750 bytes. For the case of multiple output messages, if the next message fits within the 750 byte length limit, it will be output. If any message is longer than this limit, its output will be left pending and will be scheduled when the total number of output bytes allows. The order shown in Table 4-2 is the priority order for transmitting messages. Below this priority list, the GPS Receiver Control Parameters response messages and the Utilities response messages have the lowest priority.

You can select each of the output data messages as either one-time output (polled), or output continuously (continuous) at a selected update rate. The polled or continuous option of each output message is remembered during the power-off state in the GPS Receiver nonvolatile memory.

NOTE: Every "change-parameter type" input command has a corresponding response message showing the configuration parameter change. To request the current status of the GPS Receiver, enter an input command with at least one out-of-range parameter. The response message to properly formatted commands with out-of-range parameters is to output the original unchanged value of the parameter.

4.2.2.1 Options. The GPS Receiver is capable of supporting the following optional capability via the Motorola Binary I/O Format. Basic GPS Receivers (no options installed) will not respond to, nor create, the following input/output messages listed below. In addition, the 1 PPS hardware output of the GPS Receiver I/O port is deactivated. You can install these options independently at any time. Contact Motorola for information about option installation.

Option A Timing/1 PPS Capability

- Position Hold Position
- Position Hold Enable/Disable
- Measurement Epoch Offset
- 1 PPS Time Offset
- 1 PPS Cable Delay

Option B Real-Time Differential Capability

- Position Hold Position
- Position Hold Enable/Disable
- Output Pseudorange Correction (Master Station)
- Input Pseudorange Correction (Remote Mobile)

Options C,D and E Satellite Pseudorange/ Carrier Phase Data Capability

- Satellite Range Data Output Message

There are three components of data in the satellite range data message (Carrier Phase Data, Smoothed Satellite Time data, and RAW Code Phase and Code Discriminator Data) shown in Table 4-3.

The same format for the satellite range data message applies to all three options. The data fields that are not available in the Option D and Option E receivers are zero filled.

4.2.3 NMEA-0183 Format Description. Output of data in NMEA-0183 standard format allows interface via the RS232 port to an electronic navigation instrument that supports the specific messages that are transmitted. The GPS Receiver will support the following NMEA output messages per the NMEA-0183 Revision 2.0 Specification:

GPGGA	Latitude/Longitude Message
GPRMC	GPS Transmit Specific Message
GPGLL	Latitude/Longitude Message
GPGSA	GPS DOP and Active Satellites Message

You can enable or disable each message output independently and control the update rate at which the information is output. Once enabled to output a particular message at a particular rate, the GPS Receiver remembers the settings when powered off and reconfigures itself to the same state when powered up again.

Table 4-3. Three Components of Satellite Range Data Message

DATA CONTAINED IN SAT RANGE MSG	OPTION C	OPTION D	OPTION E
Raw Code Phase & Disc Data	yes	yes	yes
Smooth Sat Time Data	yes	yes	no
Carrier Phase Data	yes	no	no

All NMEA messages are formatted in sentences that begin with ASCII $ (hex 24) and end with ASCII <CR><LF> (hex 0D and hex 0A). A five-character address occurs after the ASCII $. The first two characters are the talker ID (which is GP for GPS equipment), and the last three characters are the sentence formatter or message ID from the table above. Any number of fields and an optional checksum can occur in the sentence as long as the total number of characters does not exceed 79. Fields within the message are delimited by the ASCII comma.

The checksum is calculated by XORing the 8 data bits of each character in the sentence between, but excluding, the $ and the optional (*) or mandatory (CS) checksum. The high and low nibbles of the checksum byte are sent as ASCII characters.

You control the output of the above listed messages with Motorola NMEA format messages. Input messages are allowed in the NMEA specification, and take the form $PMOTG,,,,,*CS<CR><LF>. All input parameters are separated with comma delimiters. The P character identifies the message as Proprietary format, and the MOT is the manufacturer designator for Motorola Inc.

4.2.4 LORAN Emulation Format Description. This particular output message format is intended to emulate the position status message string from a LORAN receiver. This allows you to use the GPS receiver to replace the LORAN receiver in embedded positioning system applications.

You can request the LORAN position status message string to be output at any update rate (from 1 second to 1 hour in 1 second increments) and can operate it in a polled mode where the host can request the receiver to output the position status message upon request. The selected rate of the output message is remembered between power on-off-on sequences.

4.2.5 RTCM SC-104 Format Description. The receiver employs a decoding algorithm that allows the unit to directly decode the RTCM SC-104 differential message from the input serial port. The technique employed allows the unit to simultaneously accept the RTCM SC-104 format (6 of 8 type with two most significant bits always "01") data stream along with other receiver input commands (in either Motorola binary format or in NMEA format) on the receiver's single input RS-232 port. To input both RTCM SC-104 data as well as Motorola binary or NMEA protocol commands, there is a simple set of rules that must be employed to ensure that one type of data is not interpreted as the other. See section 4.4 RTCM SC-104 Message Decoding.

4.3 OPERATIONAL CONSIDERATIONS

4.3.1 Modes of Operation. The GPS Receiver can operate in one of two modes:

- Position Fix Mode
- Idle Mode

In the Position Fix mode the GPS Receiver automatically acquires and tracks satellites; measures the pseudorange and integrated carrier phase data to each of up to six satellites; decodes and collects satellite broadcast data; computes the GPS Receiver's position, velocity, and time; and outputs the results according to the current I/O configuration selected.

In the Idle mode, the GPS Receiver's real-time clock and battery-backed RAM are maintained, but no satellite tracking or positioning operations are performed. Power consumption is reduced slightly in this mode.

4.3.2 Time-To-First-Fix (TTFF)/Reacquisition Time. TTFF is a function of position uncertainty, time uncertainty, almanac age, and ephemeris age as described in Table 4-4. The following information assumes the GPS Receiver Antenna has full view of the sky when turned on.

Reacquisition time for all GPS satellite signals after signal obscuration is a function of the obscuration time, as shown in Table 4-5.

Table 4-4. TTFF Information

POWER-UP STATE	INITIAL ERROR			AGE		TTFF	
	POS	VEL	TIME	ALMANAC	EPHEMERIS	(typical)	(90%)
Hot	100 km	75 m/sec	3 min	1 month	≤ 4 hrs	21 sec	30 sec
Warm	100 km	75 m/sec	3 min	1 month	U/A	53 sec	66 sec
Cold - 1	N/A	N/A	U/A	1 month	U/A	7.9 min	15.0 min
Cold - 2	N/A	N/A	N/A	U/A	U/A	13.0 min	25.0 min

U/A - This parameter is assumed to not be available.
N/A - Not applicable. Knowledge of this parameter has no effect on TTFF in this configuration.

Table 4-5. Reacquisition Time

TIME OBSCURED	REACQUISITION TIME (Typical)
15 sec	< 2.5
30 sec	< 3.5
45 sec	< 3.5
60 sec	< 3.6

4.3.3 Power On-Off-On Logic.

4.3.3.1 First Time On. When the GPS Receiver powers up for the first time after factory shipment, it is configured in the Position Fix mode and Motorola Binary format. By default, the initial date and time will be incorrect. This will force the GPS Receiver into a cold power-up state (cold start), and it will begin to search the sky for all available satellites. After one satellite has been acquired, the date and time automatically will be set from the satellite. When three or more satellites are tracked, automatic position computation is initiated.

At powerdown, the GPS Receiver remembers its current configuration. This is the configuration it will be in upon the next power up.

4.3.3.2 "Keep Alive" Power Disconnect. If you disconnect the "Keep Alive" power (BATT power), then the real-time clock and the battery backed RAM memory will be erased. In this scenario, date and time are lost and the GPS Receiver will enter the cold power-up state when power is reapplied.

4.3.3.3 Motorola Binary Format Initialization. The GPS Receiver powers up in the same mode it was in the last time it was used. If it was left in the Position Fix mode, the GPS Receiver executes the satellite acquisition and tracking algorithms and will compute position when it acquires at least three satellites. The type of message output also depends on the previous state. For each of the user-requestable outputs, the receiver remembers the previously requested message state and rate (continuous or one-time) and outputs the previously requested messages. If no messages were requested continuously the last time the receiver was used, it waits for an input command before it outputs any other data, even though it may have acquired satellites and is computing position internally.

The GPS Receiver need not be initialized to its approximate user position coordinates to acquire satellite and output position, nor does it require a current satellite almanac. However, the TTFF will be considerably shorter if you help the GPS Receiver find satellites by setting the approximate initial position coordinates, setting the time and date correctly, and installing a current satellite almanac.

When it's turned off, the GPS Receiver remembers all of the user-set input parameters with the following exceptions:

- It always configures itself into the automatic satellite selection mode when power is applied. You can command the receiver into manual satellite select mode after applying power.
- After being powered down, the receiver does not remember manual satellite assignments to channels or the state of the ephemeris hold switch.

The GPS Receiver stores its last used position coordinates in nonvolatile memory and uses the information in the satellite acquisition algorithm. It also stores time and date information in an internal real-time clock so you do not have to initialize this information after you initially set the time or it is obtained from the satellites. In addition, the receiver retains the last used satellite ephemeris as long as the 5/12V_BATT signal is applied. If you move the GPS Receiver a great distance before using it again, it will find and acquire satellites, but the TTFF will be longer than normal the first time you use the receiver. You can initialize the approximate position coordinates for faster TTFF if desired.

Each parameter in the I/O format description shows the factory-set default value for each parameter.

4.3.3.4 NMEA Format Receiver Initialization. The GPS Receiver powers up in the same mode it was in the last time it was used. If it was in the Position Fix mode, it executes the satellite acquisition and tracking algorithms and will compute position when it acquires at least three satellites. The type of message output also depends on the previous state. For each of the user-requestable outputs, the GPS Receiver remembers the previously requested message state and update rate and outputs the previously requested messages. If no messages were requested the last time the GPS Receiver was used, the receiver waits for an input command before it outputs any other data, even though it may have acquired satellites and is computing position internally.

4.3.3.5 LORAN Format Receiver Initialization. The GPS Receiver powers up in the same mode it was in the last time it was used and remembers the timed position update count. If it was in the Position Fix mode, it executes the satellite acquisition and tracking algorithms and will compute position data when it acquires at least three satellites.

When you power up the receiver, it will output the first verified position (quality factor = 1) when it acquires the first three or more satellites and computes a valid position. It will then reset the timed interval counter and begin to output the data on the timed update rate.

If the GPS Receiver cannot obtain a verified position after the timed update period is completed, it will output the last known verified valid position with the Q status set to 0 and restart the timed update interval.

If the record output at the end of a timed interval contains Q = 0, the GPS Receiver will send out one more record the next time it computes valid data and the Q status will be set to 1 in this record. Timed outputs will continue without modification of the timer; that is, the timed interval will not be reset to zero coincident with the secondary Q = 1 output.

4.4 RTCM SC-104 Message Decoding

When using the RTCM SC-104 data (6 of 8 type, with two most significant bits always "01") in conjunction with either the Motorola Binary or the NMEA protocol, special care must be exercised by the user to ensure that the RTCM SC-104 data messages and the Motorola Binary/ NMEA data messages do not interfere with each other.

To better understand what the user must do to insert both RTCM SC-104 data AND either Motorola binary data or NMEA format commands, the user should understand how the receiver RS-232 message decoding software operates.

The PVT6 Receiver RS-232 decoding logic operates as follows:

The received data from the RS-232 port is placed into two buffers via interrupt driven software. Label these two data buffers B1 and B2. The Motorola binary data format and the NMEA data format is orthogonal to the RTCM data. Consequently the receiver message decoding logic first looks for Motorola format data (or NMEA data, depending on the message format selected) first by decoding

the appropriate format data from buffer B1. If any GPS input commands or data is detected in the stream, the internal software executes that command and then removes the Motorola binary data message out of buffer B1 and B2. Any remaining data left in B2 is passed to the RTCM SC-104 decode software.

The user of the PVT6 in a differential system (based on the RTCM SC-104 correction stream) can configure his system into two classes, depending on his requirements. These two configurations consist of:

1. Applications requiring real-time GPS control.

2. Applications NOT requiring real-time GPS control.

4.4.1 Applications NOT Requiring Real-Time Control. See Figure 4-1. To operate the PVT6 with a beacon receiver, the PVT6 must first be configured into its desired operating mode with the PVT6 IBM-PC controller (supplied) or the user's custom equivalent. This requires connecting the PVT6 I/O port directly to a PC with a standard serial cable, running the receiver control software, and setting the configuration desired. Configuring the receiver establishes the desired operating mode and allows the user to select which type of output data format he desires (examples, Motorola binary or NMEA).

In the differential application shown in Figure 4-1, the GPS receiver cannot be controlled by an external device while in operation as the input port is tied up by the beacon receiver input. In addition, the output port of the GPS receiver is dedicated to the user's output data logging or display system.

4.4.2 Applications Requiring Real-Time Control. In order to utilize the PVT6 core receiver's single I/O port for both input of differential corrections and receiver commands, the user must install some form of system controller between his source of the RTCM SC-104 data and the GPS receiver. Figure 4-2 shows the interconnect diagram of the GPS receiver, the beacon receiver, and the user control-display processing unit.

The GPS receiver is designed to accept its normal I/O commands and at the same time accept RTCM SC-104 format differential corrections. The user's controller-display processor acts as a traffic cop and appends user directed commands to the RTCM SC-104 decoded data before the combined data is sent to the GPS receiver.

Of course, there are some restrictions as to how the user's control-display unit appends the GI commands to the RTCM SC-104 decoded data s as to prevent data collisions and corruption These requirements, and others, are describe below.

Recommended logic to prevent data collisions is as follows:

The User Controller/Display unit can pass the RTCM SC-104 data stream directly from its beacon input port to the GPS receiver output port.

When it is time for the Control/Display unit to issue a series of commands to the GPS receiver, the Control/Display unit buffers the RTCM SC-104 data stream in a local buffer while the GPS receiver command(s) are being passed to the PVT6.

After all of the GPS receiver commands are sent to the PVT6, the Control/Display unit can then

send all buffered RTCM SC-104 data to the PVT6 without loss of any data.

The GPS receiver automatically outputs a short binary response message (@@Ck...Motorola binary format) to every correctly decoded RTCM SC-104 type 1 message received. If operating in NMEA protocol, the NMEA sentence "GGA" has a field that indicates the age of the last RTCM SC-104 type 1 correction.

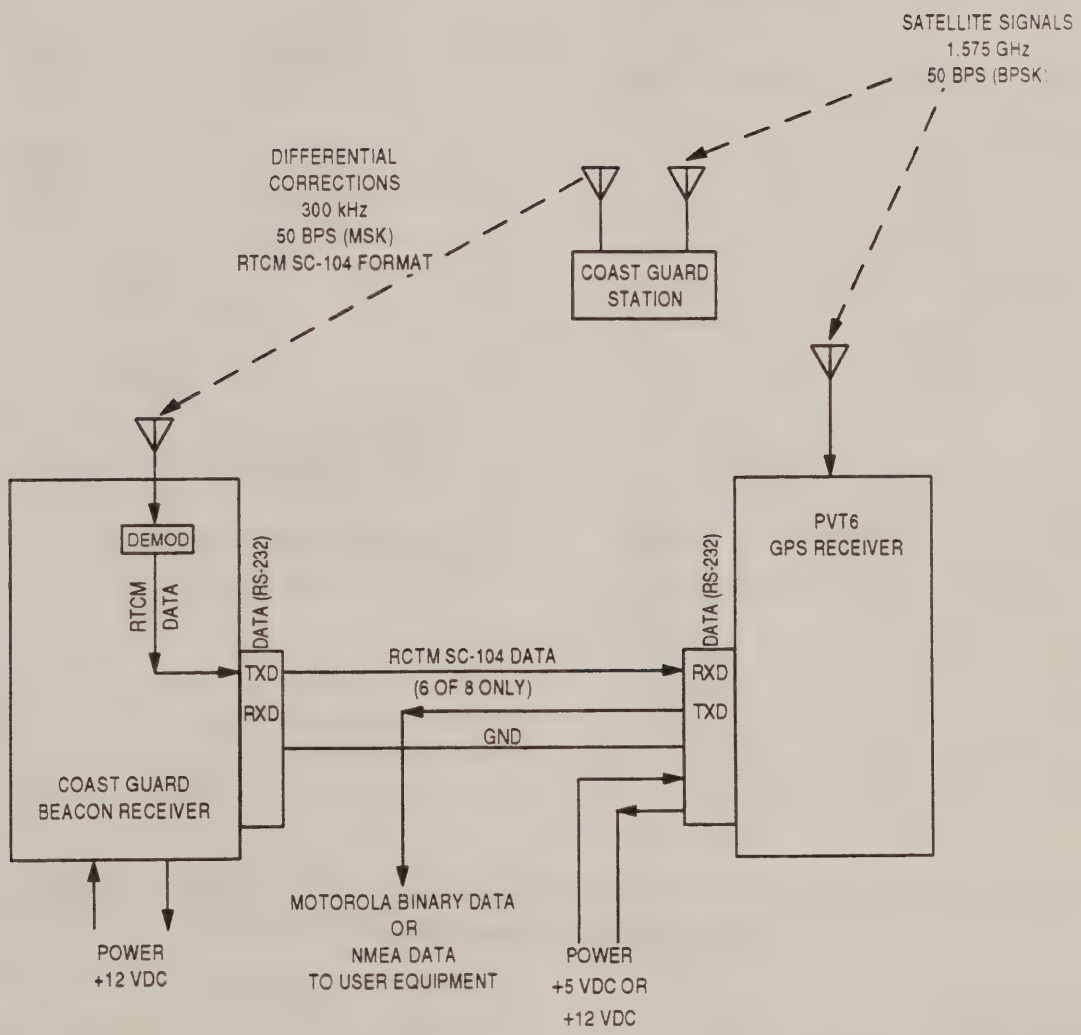


Figure 4-1. System Interconnect and Data Flow of Differential System NOT Requiring Real-Time GPS Receiver Control

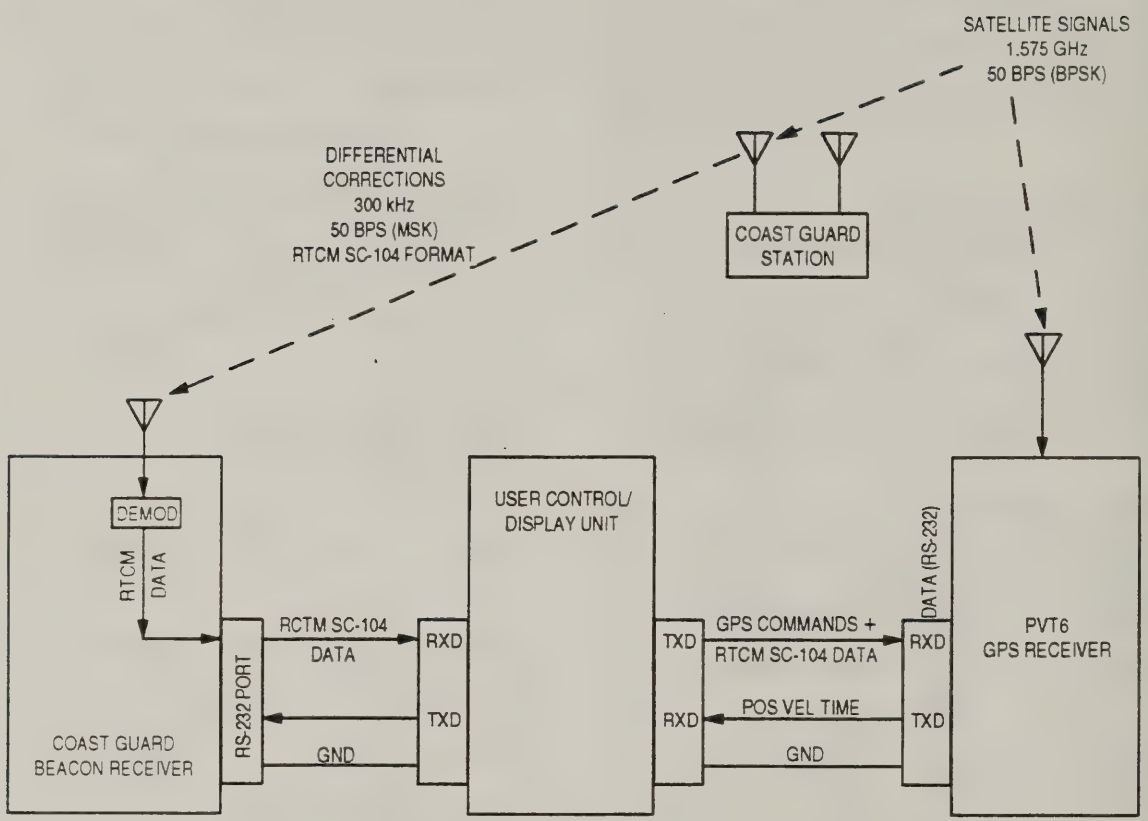


Figure 4-2. System Interconnect and Data Flow of Differential System Requiring Real-Time GPS Receiver Control

4.5 OUTPUT DATA LATENCY

The GPS Receiver outputs position, velocity, and time data on the RS232 port once each second. The start of the output data is timed to closely correspond with the receiver measurement epoch. (The measurement epoch is that point in time at which the receiver makes satellite range measurements for the purpose of computing position). The first byte of RS232 data in the position message is output between 0 and 50 msec after the most recent GPS Receiver measurement epoch.

Refer to Figure 4-3 on page 4-15 for the discussions that follow. Let T_k be the most recent measurement epoch. The GPS Receiver takes about 1 second to compute data from the satellite range measurements. Consequently, the data output 0 to 50 ms after T_k represents the best estimate of the position, velocity, and time based on the measurements taken 1 second in the past; that is, at time T_{k-1}. Position data (latitude, longitude, and height) is computed from the most recent measurement epoch data, and is available about 0.3 to 0.7 seconds after the measurements are taken.

To compensate for the 1 second computational pipeline delay, a 1 second propagated position also is computed that corresponds to T_k based on the position and velocity data computed from measurements taken at time T_{k-1}. In this way, the position data output on epoch T_k will most closely correspond with the receiver true position when the data is output on the RS232 port. Of course, there can be a position error due to the propagation process if the receiver is undergoing acceleration. The error can be as large as 4.5 meters for every G of acceleration. There is no error under stationary or constant velocity conditions.

4.5.1 Position Data Latency. The position data output in the current data packet; i.e., at time T_k, is the result of a least squares estimate (LSE) algorithm operating on satellite pseudorange measurements taken at time T_{k-1}. The resulting least squares estimate (LSE) position corresponding to time T_{k-1} is then propagated 1 second forward by the velocity vector (also the result of an LSE fit based on satellite pseudorange rate measurements taken at T_{k-1}). The resulting propagated position is output at the T_k epoch.

4.5.2 Velocity Data Latency. The velocity data output in the current data packet; i.e., at time T_k, is the result of a least squares algorithm operating on satellite pseudorange rate measurements taken at time T_{k-1}. The pseudorange rate measurements are derived from the difference in integrated carrier phase data sampled at measurement epochs T_{k-1} and T_{k-1} – 200 milliseconds. In effect, the resulting velocity data represents the average velocity of the receiver half-way between T_{k-1} and T_{k-2}.

4.5.3 Time Data Latency. The time data output in the current data packet; i.e., at time T_k, is the result of a least squares algorithm operating on satellite pseudorange measurements taken at time T_{k-1}. The time estimate at T_{k-1} is then propagated by 1 second plus the computed receiver clock bias rate at time T_{k-1} before being output at time T_k. The resulting time data is the best estimate of the local time corresponding to the T_k measurement epoch based on data available at T_{k-1}.

4.5.4 Satellite Range/Range Rate Data Latency. The satellite time data fields output in the current data packet; i.e., at time T_k, represents the time indicated by the received data for each satellite at the T_{k-1} measurement epoch. The satellite time data is precisely the same data the GPS Receiver uses in the computation of satellite pseudorange for use in its internal LSE algorithm. The satellite time data is the result of

a narrow band code tracking filter that is carrier aided. This smoothing process reduces the measurement jitter to a very small quantity, yet still allows the output position to respond to dynamic behavior with no associated filtering lag.

The raw code phase and code discriminator data is not smoothed and reflects the instantaneous code phase at the T_{k-1} measurement epoch.

The integrated carrier phase data is the instantaneous phase of the L1 carrier at the T_{k-1} measurement epoch. The data contains both integer and fractional carrier cycle data.

The "GPS local time" field in the message corresponds to the best estimate; i.e., LSE derived, of the measurement epoch time at time T_{k-1}.

4.5.5 Pseudorange Correction Data Latency. The data output in the current data packet; i.e., at time T_k, represents the corrections to pseudorange and pseudorange rate as observed by the GPS Receiver at time T_{k-1}. The "GPS time reference" field in the message corresponds to the GPS Receiver's best estimate; i.e., LSE derived, of the measurement epoch time at time T_{k-1}.

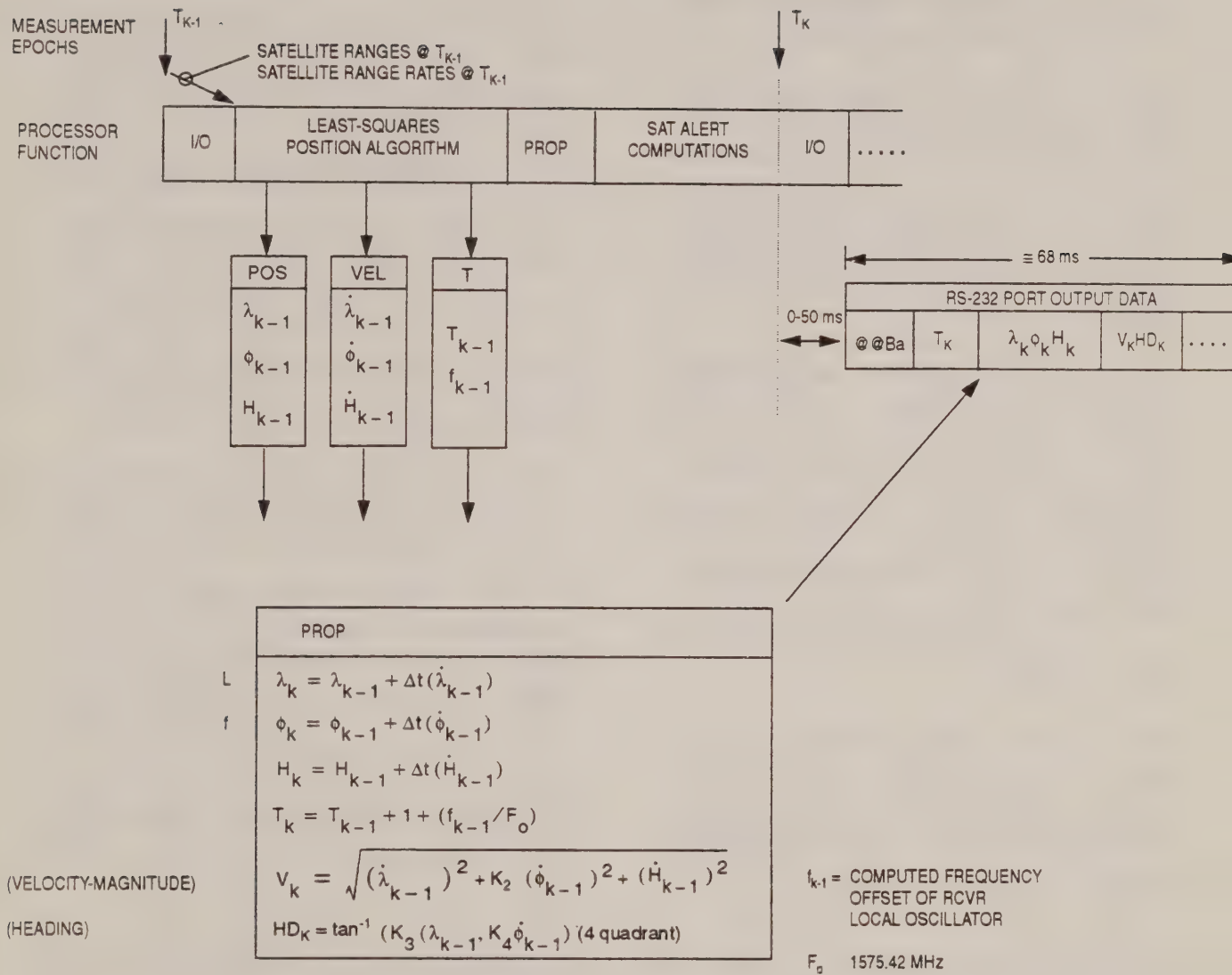


Figure 4-3. Position Channel Status Output Message Latency

4.6 ONE PULSE PER SECOND (1PPS) TIMING

4.6.1 System Timing - Measurement Epoch. The PVT6 Receiver timing is established relative to an internal, asynchronous, 1 kHz clock derived from the local oscillator. The receiver counts the 1 kHz clocks, and uses each successive 1000 clocks to define the time when the measurement epoch is to take place. The measurement epoch is the point at which the receiver captures the pseudorange and pseudorange rate measurements for computing position, velocity, and time.

When the receiver starts, it defines the first clock as the measurement epoch. Every 1000 clocks from that point define the next measurement epoch. Each measurement epoch is about 1 second later than the previous measurement epoch, where any difference from 1.000000000 seconds is the result of the receiver local oscillator intentional offset (about +13 microseconds per second) and the oscillator's inherent instability (+/- 2 parts per million).

When the PVT6 process computes receiver local time, this time corresponds to the time of the last receiver measurement epoch. This time is precisely known by the PVT process to an accuracy of approximately 20 to 300 nanoseconds depending on satellite geometry and the effects of S/A.

The PVT6 receiver allows users to specify the fractional part of time for the measurement epoch to within 1 millisecond. For example, suppose the user specifies the measurement epoch offset to be 0.123 seconds. When this occurs, the measurement epoch of the receiver is adjusted so that the fractional part of receiver local time is between 0.123000000 and 0.123999999 seconds. Time is relative to UTC or GPS time depending on the time-type as specified by the user by the UTC Time Correction Enable/Disable parameter.

The PVT6 system timing is designed to slip time when necessary in discrete 1 millisecond intervals so that the receiver local time corresponds to the desired measurement epoch offset. The PVT6 observes the error between actual receiver local time and the desired measurement epoch offset and then slips the appropriate integer milliseconds to place the measurement epoch to the correct integer millisecond. When a time skew occurs (such as after initial acquisition or to keep time within limits due to local oscillator drift), the receiver lengthens or shortens the next processing period in discrete 1 millisecond steps.

Valid range for the timing skew is -1 to +999 milliseconds. The -1 input is intended to compensate for local oscillator intentional offset. Recall that the receiver local oscillator is tuned slightly low in frequency, which causes slightly more than 1 second of time to be clicked off between each 1000 clocks. At the first fix, when the system measures time for the first time, there can be up to 999 additional milliseconds in the next 1 second interval (that is, the very next interval can be extended by up to 0.999 seconds) in order to place the measurement epoch at the user-selected value of integer millisecond time range.

4.6.2 1PPS Timing. Users can specify an offset (via the One Pulse Per Second Time Offset) for the 1PPS output anywhere between 0.000000000 to 0.999999999 seconds from the measurement epoch time. Users also can compensate for antenna cable length with the parameter One Pulse Per Second Cable Delay. The rising edge of the 1PPS is placed so that it corresponds to the time indicated by the following equation:

1PPS Rising Edge Time =

Measurement Epoch Offset Time + 1PPS Offset Time - 1PPS Cable Delay Time

Consider the following example:

Meas Epoch Offset Time =0.100(+)

1PPS Offset Time =0.500987654(+)

1PPS Cable Delay Time =0.000654321(–)

TOTAL: 1PPS Rising Edge Time =0.600333333

The rising edge of the 1PPS signal is adjusted so that it occurs corresponding to the fractional part of time equal to the total above. The fractional part of time is measured relative to UTC time or GPS time depending on the setting of the UTC Time Correction Enable/Disable parameter.

The rising edge of the 1PPS signal is the time reference. The falling edge will occur approximately 200 milliseconds (+/–1 ms) after the rising edge. The falling edge should not be used for accurate time keeping.

4.6.3 Output Data Timing Relative to Measurement Epoch. The receiver outputs six messages containing time information:

1. Position/Status/Data Output Message (hours, minutes, seconds, fractional seconds)

2. Satellite Range Data Output Message (GPS local time in integer and fractional seconds)

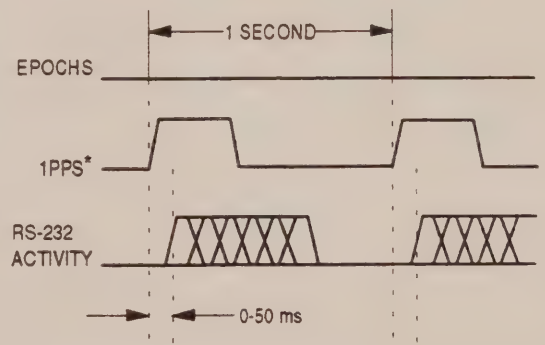
3. Pseudorange Correction Message (GPS reference time for the corrections)

4. NMEA GPGGA Message (hours, minutes, seconds, hundredths of second)

5. NMEA GPRMC Message (hours, minutes, seconds, hundredths of second)

6. NMEA GPGLL Message (hours, minutes, seconds, hundredths of second)

These six messages, if enabled, will be output from the receiver shortly after a measurement epoch. Generally, the first data byte in the first message will be output between 0 to 50 milliseconds after a measurement epoch. For the Position/Status/Data message as well as all of the NMEA messages, the time output in the message reflects the best estimate of the most recent measurement epoch. For the Satellite Range Data message and the Pseudorange Correction message, the time data indicates the best estimate of the measurement epoch two epochs ago (that is, approximately 1.0 to 1.05 seconds ago). A simple timing diagram is shown below.



* 1PPS OFFSET AND 1PPS CABLE DELAY = 0

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I/O COMMAND SECTION

4.7 I/O COMMANDS

4.7.1 Motorola Binary Format.

TIME OF DAY

This input command changes the current time in the GPS Receiver to the time specified in the command. The time normally will be correct because it is updated by an internal real-time clock. It is not necessary for the user to enter the time of day if power is removed, however the TTFF will be greatly reduced if the time is initialized. The GPS Receiver corrects the time data in the real-time clock with time information decoded from the satellite broadcast data. The GMT Correction parameter first must be specified before this "Change Current Time of Day" input command is sent to the GPS Receiver.

The user can send the "Change Current Time of Day" command in either the Position Fix mode, or the Idle mode. However, if the GPS Receiver has acquired at least one satellite in the Position Fix mode, it will ignore this command since it obtains time information from the satellites as a normal part of tracking. For this reason, the user must place the GPS Receiver in the Idle mode in order to change the time if the unit is in the Position Fix mode and is already tracking at least one satellite. The GPS Receiver will accept and execute the "Change Current Time of Day" command if it is in the Position Fix mode and the GPS Receiver has yet to acquire the first satellite.

Time is stored as local time or GMT time, depending on the setting of the GMT Correction parameter. The GPS Receiver automatically compensates for leap-second corrections, thus the response message can contain "seconds" parameter equal to 60. Leap seconds are inserted approximately once per year.

Range: 00:00:00 to 23:59:59

Default value: Time not changed

INPUT COMMAND DESCRIPTION:

- Send Current Time of Day:

  @@AaxxxC<CR><LF>

  xxx – $ffffff (three bytes, all hex ff)
  C – checksum
  Message Length: 10 bytes

- Change Current Time of Day:

  @@AahmsC<CR><LF>

h – hours	0 .. 23
m – minutes	0 .. 59
s – seconds	0 .. 59

  Message Length: 10 bytes

RESPONSE MESSAGE:

- *(to either command):*

  @@AahmsC<CR><LF>

h – hours	0 .. 23
m – minutes	0 .. 59
s – seconds	0 .. 60

  C – checksum
  Message Length: 10 bytes

TIME OF DAY

MOTOROLA BINARY FORMAT

GMT CORRECTION

This command changes the correction factor between GMT and local time. The GPS Receiver computes local time from GMT time and the correction factor by the equation:

LOCAL TIME = GMT_TIME
+GMT_CORRECTION

The minutes correction is provided for those locations in the world that do not use an even offset of hours between GMT and local time. If it is desired to operate on GMT time, the correction is set to 0 hours, 0 minutes and the time set in the Time of Day parameter must be entered in GMT time.

Range: hours: -12 to +12
minutes: 00 to 59

Default value: 00:00 (No GMT Correction)

INPUT COMMAND DESCRIPTION:

- Send Current GMT Correction:

  @@AbxxxC<CR><LF>

  xxx – $ffffff (three bytes, all hex ff)
  C – checksum
  Message Length: 10 bytes

- Change Current GMT Correction:

  @@AbshmC<CR><LF>

s – sign	00 – positive
	ff – negative
h – hours	0 .. 12
m – minutes	0 .. 59

C – checksum
Message Length: 10 bytes

RESPONSE MESSAGE:

- (to either command):

  @@AbshmC<CR><LF>

s – sign	00 – positive
	ff – negative
h – hours	0 .. 12
m – minutes	0 .. 59

C – checksum
Message Length: 10 bytes

GMT CORRECTION

MOTOROLA BINARY FORMAT

DATE

This command changes the current date in the GPS Receiver real-time clock to the date specified in the input command. The date in the Receiver normally will be correct because it is updated by the internal real-time clock. It is not necessary for the user to enter the current date if the real time clock power is removed, however the TTFF will be greatly reduced if the date is initialized. The GPS Receiver corrects the date data in the real-time clock with date information decoded from the satellite broadcast data. The GMT Correction parameter must first be specified before the "Change Current Date" input command is sent to the GPS Receiver.

The user can send the GPS Receiver a "Change Current Date" command in either the Position Fix mode, or the Idle mode. However, if the GPS Receiver has acquired at least one satellite in the Position Fix mode, it will ignore this command since it obtains date information from the satellites as a normal part of tracking. For this reason, the user must place the GPS Receiver in the Idle mode in order to change the GPS Receiver date if the GPS Receiver is in the Position Fix mode and is already tracking at least one satellite. The GPS Receiver will accept and execute the "Change Current Date" command if it is in the Position Fix mode and the GPS Receiver has yet to acquire the first satellite.

INPUT COMMAND DESCRIPTION:

- Send Current Date:

  @@AcxxxxC<CR><LF>

  xxxx – $ffffffff (four bytes, all hex ff)
  C – checksum
  Message Length: 11 bytes

- Change Current Date:

  @@AcmdyyC<CR><LF>

m – month	1 .. 12
d – day	1 .. 31
yy – year	1980 .. 2077

C – checksum
Message Length: 11 bytes

RESPONSE MESSAGE:

- *(to either command)*

  @@AcmdyyC<CR><LF>

m – month	1 .. 12
d – day	1 .. 31
yy – year	1980 .. 2077

C – checksum
Message Length: 11 bytes

LATITUDE

NOTE: The following three parameters are used to establish the initial position of the GPS Receiver. The initial position estimate provides the GPS Receiver with a starting point to begin the satellite acquisition process. It is not necessary for the user to initialize the coordinates with a position estimate, however the TTFF will be minimized by providing an estimate that is close to the user's position.

Latitude is measured in degrees north (+) or degrees south (-) of the earth equator. The datum for the latitude is specified by setting the Datum ID parameter. This input command sets the initial latitude coordinate if the GPS Receiver is not computing a position fix, or is used to replace the current latitude with a new latitude while in the Position Fix mode.

Range: -90 (South Pole) to +90 (North Pole) degrees latitude
Default value: 0 latitude (Equator)
Units: msec (1° = 3600 sec)

INPUT COMMAND DESCRIPTION:

- Send Current Latitude:

  @@AdxxxxC<CR><LF>

  xxxx = $99999999 (four bytes, all hex 99)
  C – checksum
  Message Length: 11 bytes

- Change Current Latitude:

  @@AdddddC<CR><LF>

  dddd – latitude in msec -324,000,000 .. 324,000,000 (-90° to +90°)

  C – checksum
  Message Length: 11 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@AdddddC<CR><LF>

  dddd – latitude in msec -324,000,000 .. 324,000,000 (-90° to +90°)

  C – checksum
  Message Length: 11 bytes

  Note: 1 degree latitude equals 3,600 sec or 3,600,000 msec

LATITUDE

MOTOROLA BINARY FORMAT

LONGITUDE

Longitude is measured in degrees west (-) or degrees east (+) of the Greenwich Meridian. The datum for the longitude is specified by setting the Set Datum ID parameter. This input command sets the initial longitude coordinate if the GPS Receiver is not computing a fix, or is used to replace the current longitude with a new input longitude while in the Position Fix mode.

Range: -180 to +180 degrees longitude
Default value: 0 longitude (Greenwich Meridian)
Units: msec (1° = 3600 sec)

INPUT COMMAND DESCRIPTION:

- Send Current Longitude:

  @@AexxxxC<CR><LF>

  xxxx = $99999999 (four bytes, all hex 99)
  C – checksum
  Message Length: 11 bytes

- Change Current Longitude:

  @@AeddddC<CR><LF>

  dddd – longitude in msec -648,000,000 ..
  648,000,000
  (-180° to +180°)

  C – checksum
  Message Length: 11 bytes

RESPONSE MESSAGE:

- *(to either command)*

  @@AeddddC<CR><LF>

  dddd – longitude in msec -648,000,000 ..
  -648,000,000
  -(-180° to +180°)

  C – checksum
  Message Length: 11 bytes

  Note: 1 degree longitude equals 3,600 sec or 3,600,000 msec.

LONGITUDE

MOTOROLA BINARY FORMAT

HEIGHT

This command sets the initial height coordinate if the GPS Receiver is not computing a position fix, or is used to replace the current height with a new input height while in the Position Fix mode. The user can enter the height in either of two references:

- GPS Ellipsoid Height – The height above the reference ellipsoid
- MSL Height – The height above mean sea level

The units are meters. If the "Change Current Height" command is performed while the GPS Receiver is in the Position Fix mode, the height parameter is set to the new value entered.

Range: -1000.00 to 18000.00 meters
Default value: 0.00 meters
Resolution: 0.01 meter

INPUT COMMAND DESCRIPTION:

- Send Current Height:

  @@Afxxxxx**C**<CR><LF>

  xxxx = $9999999999 (five bytes, all hex 99)
  C – checksum
  Message Length: 12 bytes

- Change Current Height:

  @@Afhhhht**C**<CR><LF>

  hhhh – height in cm -100000 .. 1,800,000
  (-1000.00 to+18000.00 meters)
  t – height type 0 = ellipsoid height
  1 = msl height
  C – checksum
  Message Length: 12 bytes

RESPONSE MESSAGE:

- *(to either command)*

  @@Afhhhhmmmm**C**<CR><LF>

  hhhh – height in cm -100000 .. 1,800,000
  (GPS Ellipsoid Height)(-1000.00 to +18000.00 meters)
  mmmm – height in cm -100000 .. 1,800,000
  (MSL Height) (-1000.00 to +18000.00 meters)
  C – checksum
  Message Length: 15 bytes

HEIGHT

MOTOROLA BINARY FORMAT

SATELLITE MASK ANGLE

The GPS Receiver will attempt to track satellites for which the elevation angle is greater than the satellite mask angle. This parameter allows the user to control the elevation angle that was used for this decision.

Range: 0 to 89 degrees
Default value: 10 degrees

INPUT COMMAND DESCRIPTION:

- Send Current Satellite Mask Angle:

  @@AgxC<CR><LF>

  x = $ff (one byte, hex ff)
  C – checksum
  Message Length: 8 bytes

- Change Satellite Mask Angle:

  @@AgdC<CR><LF>

  d – degrees 0 .. 89
  (8 bit unsigned binary)
  C – checksum
  Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to either command):*

  @@AgdC<CR><LF>

  d – degrees 0 .. 89
  C – checksum
  Message Length: 8 bytes

SATELLITE MASK ANGLE

MOTOROLA BINARY FORMAT

SATELLITE SELECT OPTIONS

This command sets the Satellite Select option to either automatic or manual satellite selection. With the "automatic best geometry" satellite select option enabled, the GPS Receiver automatically selects the set of satellites to track with the best geometry (selection criteria optimized for the selected xDOP type, the xDOP hysteresis parameter and position fix type). With the automatic satellite select option enabled, the GPS Receiver will change satellites to maintain the set with the best geometry based on each new computation of satellite geometry. Selection of the manual satellite select option requires the user to select the satellites to be tracked.

With the "automatic highest-in-sky" mode, the receiver simply tracks the six satellite currently highest above the horizon.

With the highest-in-the-sky option enabled, the receiver will select satellites to track based on their elevation angle. Use of this option will result in more position fixes in concrete canyon environments when more than six satellites are visible at the expense of accuracy since geometry is not considered as a satellite selection criterion when this option is selected

The GPS Receiver will power-up to either automatic or highest-in-the-sky, depending on which option was last selected by the user. The receiver will never power-up in manual mode.l When manual mode is selected the receiver will continue to track those satellites set by either the automatic or highest-in-the-sky selection processes when the Satellite Select option is set to manual satellite select. The user can then change any satellite on any channel using the Manual Satellite Select command.

The GPS Receiver always defaults to the automatic satellite mode last used option when the GPS Receiver is powered-up. The GPS Receiver continues to track those satellites set by automatic satellite selection processes when the Satellite Select option is set to manual satellite select. The user can then change any satellite on any channel using the Manual Satellite Select command.

Default value: Automatic

INPUT COMMAND DESCRIPTION:

- Send Current Satellite Select:

  @@AhxC<CR><LF>

  x = $ff (one byte, hex ff)
  C – checksum
  Message Length: 8 bytes

- Change Satellite Select:

  @@AhoC<CR><LF>

  o – option 0 – automatic
  1 – manual
  C – checksum 2 – automatic highest-in-sky
  Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@AhoC<CR><LF>

  0 – option 0 – automatic
  1 – manual
  C – checksum 2 – automatic highest-in-sky
  Message Length: 8 bytes

SATELLITE SELECT OPTIONS

MOTOROLA BINARY FORMAT

SATELLITE SELECT

This option is used to manually change the satellites tracked. This input command is used by the GPS Receiver only when the Manual Satellite Select option is enabled. The input command has no effect if the Automatic Satellite Select option is enabled.

INPUT COMMAND DESCRIPTION:

- Send Current Satellite Assignment on Channel:

  @@AicxC<CR><LF>

  c – Channel number 1 .. 6
  x = $ff (one byte, hex ff)
  Message Length: 9 bytes

- Change Satellite Assignment on Channel:

  @@AicsC<CR><LF>

  c – channel number 1 .. 6
  s – sat ID per channel 0 .. 37
  0 – disable channel
  1..37 - sat ID including pseudolite IDs
  C – checksum
  Message Length: 9 bytes

RESPONSE MESSAGE:

- *(to either command)*

  @@AicsC<CR><LF>

  c – channel number 1 .. 6
  s – sat ID per channel 0 – disable channel
  1..37 – sat ID including pseudolite IDs
  C – checksum
  Message Length: 9 bytes

SATELLITE SELECT

MOTOROLA BINARY FORMAT

xDOP TYPE

The xDOP Type parameter specifies which DOP type to use for satellite selection criteria. The user has the choice of allowing the GPS Receiver to optimize its satellite selection based on minimum value of the chosen DOP type as defined by the following table:

PARAM	DEFINITION	GEOMETRY CONSIDERED
GDOP	Geometric Dilution of Precision	X, Y, Z, T
PDOP	Position Dilution of Precision	X, Y, Z
HDOP	Horizontal Dilution of Precision	X, Y
VDOP	Vertical Dilution of Precision	Z
TDOP	Time Dilution of Precision	T

Default value: PDOP

INPUT COMMAND DESCRIPTION:

- Send Current xDOP Type:

  @@AjxC<CR><LF>

  x = $ff (one byte, hex ff)
  C - checksum
  Message Length: 8 bytes

- Change xDOP Type:

  @@AjdC<CR><LF>

  d – DOP Type
  0 – GDOP
  1 – PDOP
  2 – HDOP
  3 – VDOP
  4 – TDOP

  C – checksum
  Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to either command)*

  @@AjdC<CR><LF>

  d - DOP Type
  0 – GDOP
  1 – PDOP
  2 – HDOP
  3 – VDOP
  4 – TDOP

  C – checksum
  Message Length: 8 bytes

xDOP TYPE

MOTOROLA BINARY FORMAT

xDOP HYSTERESIS

Setting this parameter allows the user to change the criteria by which the GPS Receiver selects satellites. The GPS Receiver evaluates the geometry for all satellites in view every few seconds. In doing so, it evaluates every combination of four or six visible satellites (based on the Position Fix Algorithm Type selection), computes an xDOP parameter for each combination (xDOP type as selected) and sorts them into ascending order. If three or four satellites are visible, the GPS Receiver tracks the visible satellites and computes position without regard to geometry (xDOP) since these satellites represent the only choice at that time. However, if five satellites are visible, then five combinations of four satellites are possible for navigation (with the Position Fix Algorithm Type set for "Best-4." The GPS Receiver computes an xDOP for each combination and determines position from the set of four satellites corresponding to the best xDOP, leaving any remaining satellites that are tracked in reserve for use if one or more of the primary four satellites are lost momentarily. With the Position Fix Algorithm Type set for "N-in-View," the GPS Receiver compares the closeness of xDOP for all combinations of visible satellites greater than six.

There are periods in the satellite pass where the relative difference in xDOP among the many satellite combinations is small, and the GPS Receiver would switch satellites needlessly if it were not for this parameter. To combat this, the xDOP hysteresis command can be used. When set to a nonzero number, a threshold on the change in xDOP is added to the satellite selection criteria. If the parameter is set to zero, then the GPS Receiver will select the best satellites after every satellite alert computation without regard to the "closeness" of xDOP. If the parameter is set relatively high, then the receiver will switch satellites only if the geometry on the tracked satellites becomes very poor, or if one of the tracked satellites goes below the satellite elevation mask angle.

Range: 1.0 to 99.9
Default value: 1.0
Resolution: 0.1

INPUT COMMAND DESCRIPTION:

- Send Current xDop Hysteresis:

  @@AkxxC<CR><LF>

  xx – $ffff (two bytes, all hex ff)
  C – checksum
  Message Length: 9 bytes

- Change xDop Hysteresis:

  @@AkxxC<CR><LF>

  xx – xDop Hysteresis 0 .. 999
  0.1 resolution (0.0 .. 99.9)
  C – checksum
  Message Length: 9 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@AkxxC<CR><LF>

  xx – xDop hysteresis 0 .. 999
  0.1 resolution (0.0 .. 99.9)
  C – checksum
  Message Length: 9 bytes

xDOP HYSTERESIS

MOTOROLA BINARY FORMAT

3-D TO 2-D xDOP THRESHOLD

There are periods in the satellite pass where the 3-dimensional (3-D) dilution of precision (PDOP and GDOP) grows very large, but the 2-D HDOP stays relatively small. This command allows the user to set the DOP threshold above which the GPS Receiver will switch from 3-D positioning to altitude-hold at the current height. This allows the GPS Receiver to maintain a relatively accurate position fix, and avoids the condition of a 3-D fix algorithm singularity.

Range: 1.0 to 99.9
Default value: 8.0
Resolution: 0.1

INPUT COMMAND DESCRIPTION:

- Send Current 3-D to 2-D DOP threshold:

@@A1xxC<CR><LF>
(note second letter "L" not "1")

xx – $ffff (two bytes, all hex ff)
C – checksum
Message Length: 9 bytes

- Change Satellite Ignore List:

@@A1xxC<CR><LF>

xx – threshold	10 . . 999
(0.1 resolution)	(1.0 . . 99.9)

C – checksum
Message Length: 9 bytes

RESPONSE MESSAGE:

- *(to either command)*:

@@A1xxC<CR><LF>

xx – threshold	10 . . 999
(0.1 resolution)	(1.0 . . 99.9)

C – checksum
Message Length: 9 bytes

3-D TO 2-D xDOP THRESHOLD

MOTOROLA BINARY FORMAT

2-D TO 0-D HDOP THRESHOLD

There are periods in the satellite pass where the 2-dimensional (2-D) dilution of precision (HDOP) grows very large, and the position is too inaccurate for use. This command allows the user to set the DOP threshold ahove which the GPS Receiver will quit 2-D positioning.

Range: 1.0 to 99.9
Default Value: 12.0
Resolution: 0.1

INPUT COMMAND DESCRIPTION:

- Send Current 2-0 to 0-D DOP threshold:

  @@ACxxC<CR><LF>

  xx – $ffff (two bytes, all hex ff)
  C – checksum
  Message Length: 9 bytes

- Change Current 2-0 to 0-D threshold:

  @@ACttC<CR><LF>

  tt – 2-0 to 0-D threshold (0.1 resolution) — 0.. 999 (0.0.. 99.9)

  C – checksum
  Message Length: 9 bytes

RESPONSE MESSAGE:

- (to either command):

  @@ACttC<CR><LF>

  tt – 2-D to 0-D threshold (0.1 resolution) — 10..999 (1.0.. 99.9)

  C – checksum
  Message Length: 9 bytes

2-D TO 0-D HDOP THRESHOLD

MOTOROLA BINARY FORMAT

SATELLITE IGNORE LIST

It is useful to have the flexibility to delete particular satellite identifications (IDs) from the selection process. The GPS Receiver includes, in its list of satellites to track, all satellites that are healthy and in the almanac. The user can elect to ignore particular satellites in the almanac by issuing an Ignore Satellite Command. In addition, the user can restore any previously ignored satellite IDs by issuing an Include Satellite Command. This command also affects the satellite Alert-Planning settings. Satellites that have been removed by this command are not included in the produced Alert-Planning output. The user may notice a delay between issuing this command and the actual removal or inclusion of particular satellites.

Default value: All satellite IDs included.

INPUT COMMAND DESCRIPTION:

- Send Current Satellite Ignore List:

  @@AmxxxxxC<CR><LF>

  xxxxx - $ff00000000 (five bytes, hex ff00000000)
  C – checksum
  Message Length: 12 bytes

- Change Satellite Ignore List:

  @@AmkssssC<CR><LF>

  k – 00 fixed binary constant
  ssss - 32 bit binary field,
  Each bit represents one SVID
  (MSB = SVID 32
  LSB = SVID 1) 1 – Ignore
  0 – Include

  C – checksum
  Message Length: 12 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@AmkssssC<CR><LF>

  k – 00 fixed binary constant
  ssss – 32 bit binary field,
  Each bit represents one SVID
  (MSB = SVID 32
  LSB = SVID 1) 1 – Ignore
  0 – Include

  C – checksum
  Message Length: 12 bytes

SATELLITE IGNORE LIST

MOTOROLA BINARY FORMAT

ALMANAC UPDATE OPTION

The user has the flexibility of allowing or disallowing the GPS Receiver to update its internal almanac when a new one is received. With the automatic almanac update enabled, the GPS Receiver continuously will gather the satellite-transmitted almanac from any of the active channels and compare the new almanac to the old one stored in its nonvolatile memory. When a new almanac is received, the GPS Receiver will store the new almanac to nonvolatile memory and begin the process again.

With the no-update almanac option enabled, the GPS Receiver will not obtain a new almanac from the received satellite signal.

Default value: Automatic

INPUT COMMAND DESCRIPTION:

- Send Current Almanac Update Mode:

  @@AnxC<CR><LF>

  x – $ff (one byte, hex ff)
  Message Length: 8 bytes

- Change Almanac Update Mode:

  @@AnmC<CR><LF>

  m – mode 1 – Update
  0 – No-Update

  C – checksum
  Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@AnmC<CR><LF>

  m – mode 1 – Update
  0 – No-Update

  IC – checksum
  Message Length: 8 bytes

ALMANAC UPDATE OPTION

MOTOROLA BINARY FORMAT

DATUM ID CODE

The GPS Receiver has 49 predefined datums in its internal memory and two user definable datums. The datums are referenced by an ID number. The predefined datums are numbered 1 through 49 and the user defined datums are numbered 50 and 51. A table of the ID number vs datum name is provided in Appendix C. The user instructs the GPS Receiver which datum to use by sending the "Change Datum ID Number" command. The command contains the ID number of the desired datum and the GPS Receiver returns the response message which gives the user the ability to validate that the input command was accepted. The user can instruct the GPS Receiver to use one of the two user defined datums by sending the "Change Datum ID Number" command with the datum ID set to 50 or 51. Datum IDs 50 and 51 are set at the factory to default to WGS-84 parameters.

Default Datum: WGS-84 (ID code 49)

INPUT COMMAND DESCRIPTION:

- Output Current Datum ID Number:

  @@AodC<CR><LF>

  d – $ff (one byte, hex ff)
  C – checksum
  Message Length: 8 bytes

- Change Datum ID Number:

  @@AodC<CR><LF>

  d – Datum ID 1 .. 51
  C – checksum
  Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@ApdsssffiiffffxxyyzzC<CR><LF>

  d – datum ID 1 .. 51
  sssff – semi-major axis
  sss – integer part 6,000,000 .. 7,000,000 (6,000,000.0 .. 7,000,000.0)
  ff – fractional part 0 .. 999 (0.0 .. 0.999)
  iiffff – inverse flattening
  ii – integer part 285 .. 305 (285.0 .. 305.0)
  ffff – fractional part 0 .. 999,999,999 (0.0 .. 0.999999999)
  xx – delta X -32768 .. 32767
  0.1 meter resolution (-3276.8 .. 3276.7)
  yy – delta Y -32768 .. 32767
  0.1 meter resolution (-3276.8 .. 3276.7)
  zz – delta Z -32768 .. 32767
  0.1 meter resolution ? (-3276.8 .. 3276.7)
  C – checksum
  Message Length: 25 bytes

DATUM ID CODE

MOTOROLA BINARY FORMAT

USER DEFINED DATUMS

The GPS Receiver has two user defined datums stored in Datum ID numbers 50 and 51. The following commands allow the user to define the constants used for a custom datum given a semi-major axis; an inverse flattening constant; and delta-X, delta-Y, and delta-Z parameters.

Default: User defined datums are factory set to WGS-84 parameters.

INPUT COMMAND DESCRIPTION:

- Output User Defined Datum Parameters:

@@ApdxxxxxxxxxxxxxxxxxxC<CR><LF>

d – Desired User Datum 50 or 51
xxxxxxxxxxxxxxxxx (17 bytes, all hex 00)
C – Checksum
Message Length: 25 bytes

- Change User Defined Datum Parameters:

@@ApdsssffiiffffxxyyzzC<CR><LF>

d – Datum ID	50 .. 51
sssff – semi-major axis	
sss – integer part	6,000,000 .. 7,000,000 (6,000,000.0 .. 7,000,000.0)
ff – fractional part	0 .. 999 (0.0 .. 0.999)
iiffff – inverse flattening	
ii – integer part	285 .. 305 (285.0 .. 305.0)
ffff – fractional part	0 .. 999,999,999 (0.0 .. 0.999999999)
xx – delta X	-32768 ..32767
0.1 meter resolution	(-3276.8 .. 3276.7)
yy – delta Y	-32768 .. 32767
0.1 meter resolution	(-3276.8 .. 3276.7)
zz – delta Z	-32768 .. 32767
0.1 meter resolution	(-3276.8 .. 3276.7)

C – checksum
Message Length: 25 bytes

RESPONSE MESSAGE:

- *(to either command)*:

@@ApdsssffiiffffxxyyzzC<CR><LF>

d – datum ID	50 .. 51
sssff – semi-major axis	
sss – integer part	6,000,000 .. 7,000,000 (6,000,000.0 .. 7,000,000.0)
ff – fractional part	0 .. 999 (0.0 .. 0.999)
iiffff – inverse flattening	
ii – integer part	285 .. 305 (285.0 .. 305.0)
ffff – fractional part	0 .. 999,999,999 (0.0 .. 0.999999999)
xx – delta X	-32768 .. 32767
0.1 meter resolution	(-3276.8 .. 3276.7)
yy – delta Y	-32768 .. 32767
0.1 meter resolution	(-3276.8 .. 3276.7)
zz – delta Z	-32768 .. 32767
0.1 meter resolution	(-3276.8 .. 3276.7)

C – checksum
Message Length: 25 bytes

IONOSPHERE CORRECTION OPTION

The user has the flexibility of turning the GPS ionospheric correction on or off. The correction does a reasonable job of taking out the range error induced by the earth's ionosphere by using an algorithm and parameters transmitted to the users by the satellites. Some users (i.e., differential systems) choose to disable the ionospheric model.

Default value: Enabled

INPUT COMMAND DESCRIPTION:

- Send Current Ionospheric Correction Selection:

  @@AqxC<CR><LF>

  x – $ff (one byte, hex ff)
  C – checksum
  Message Length: 8 bytes

- Change Ionospheric Correction Selection:

  @@AqsC<CR><LF>

  s – selection 0 – disabled
  1 – enabled

  C – checksum
  Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@AqsC<CR><LF>

  s – selection 0 – disabled
  1 – enabled

  C – checksum
  Message Length: 8 bytes

IONOSPHERE CORRECTION OPTION

MOTOROLA BINARY FORMAT

POSITION FIX ALGORITHM TYPE

The GPS Receiver uses a least-squares position computation algorithm, and operates in one of two Position Fix modes as set by the user: Best-4 or N-in-View.

Best-4: When enabled, the GPS Receiver uses the best four satellites out of N satellites that the GPS Receiver can track for the computation of position, where N is the number of satellites that the receiver is currently tracking. The GPS Receiver can track up to six satellites, on the six channels, but only uses the best four satellites as defined by the xDOP selection. The GPS Receiver can have up to two other satellites on the remaining two channels that the receiver will use in the case that one or more of the primary selected satellites is lost due to signal blockage.

N-in-View: When enabled, the GPS Receiver will use for position fix all satellites that it is tracking (up to six). The assignment of satellites to channels is optimized for the N-in-View condition.

Default value: N-in-View

INPUT COMMAND DESCRIPTION:

- Send Current Position Fix Algorithm Type:

  @@ArxC<CR><LF>

  x – $ff (one byte, hex ff)
  C – checksum
  Message Length: 8 bytes

- Change Position Fix Algorithm Type:

  @@ArsC<CR><LF>

  s – selection 0 – Best-4
  1 – N-in-View

  C – checksum
  Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@ArsC<CR><LF>

  s – selection 0 – Best-4
  1 – N-in-View

  C – checksum
  Message Length: 8 bytes

POSITION FIX ALGORITHM TYPE

MOTOROLA BINARY FORMAT

HOLD POSITION PARAMETERS

NOTE: The input/output messages described here are available only if GPS Receiver Options A or B are installed.

The user can specify receiver coordinates for position-hold applications such as timing and real-time differential master stations. This command is used when the Hold Position option is enabled, to instruct the GPS Receiver the position to be held, and to have a means of manually enabling/disabling the position-hold function on and off. The position to be held is specified in the same units as the initial position coordinates of latitude, longitude, and height (to the same resolution). The height parameter can be referenced to either the GPS reference ellipsoid height or to mean sea level. The datum specifying the coordinate system for the fixed position coordinates must be the same as the coordinate system specified by the datum currently in use.

Default: Latitude = 0; Longitude = 0; Height = 0

INPUT COMMAND DESCRIPTION:

- Send Current Position-Hold Position:

@@AsxxxxxxxxxxxxxC<CR><LF>

xxxxxxxxxxx = $7fffffff7fffffff7fffffff (13 bytes)
C – checksum
Message Length: 20 bytes

- Change Current Position:

@@AsllllooooohhhhtC<CR><LF>

llll – latitude in msec -324,000,000 .. 324,000,000
(-90° to +90°)
oooo – longitude -648,000,000 ..
in msec 648,000,000
(-180° to +180°)
hhhh – height in cm -100000 .. 1,800,000
(-1000.00 to +18000.00)
t – height type 0 – GPS ellipsoid height ref
1 – msl ref
C – checksum
Message Length: 20 bytes

RESPONSE MESSAGE:

- (to either command):

@@AsllllooooohhhhtC<CR><LF>

llll – latitude in msec -324,000,000 .. 324,000,000
(-90° to +90°)
oooo – longitude -648,000,000 ..
in msec 648,000,000
(-180° to +180°)
hhhh – height in cm -100000 .. 1,800,000
(-1000.00 to +18000.00)
t – height type 0 – GPS ellipsoid height ref
1 – Msl ref
C – checksum
Message Length: 20 bytes

Note: 1 degree equals 3,600 seconds or 3,600,000 msec

HOLD POSITION PARAMETERS

MOTOROLA BINARY FORMAT

POSITION-HOLD OPTION

NOTE: The input/output messages described here are available only if GPS Receiver Options A or B are installed.

The user can specify coordinates for positionhold applications such as timing and real-time differential applications. This option enables/disables the Hold Position Parameters entered into the GPS Receiver.

Default value: Disabled

INPUT COMMAND DESCRIPTION:

- Send Current Position Hold Mode:

  @@AtxC<CR><LF>

  x – $ff (one byte, hex ff)
  C – checksum
  Message Length: 8 bytes

- Change Position Hold Mode:

  @@AtmC<CR><LF>

  m – mode 0 – Disabled
  1 – Enabled
  C – checksum
  Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@AtmC<CR><LF>

  m – mode 0 – Disabled
  1 – Enabled
  C – checksum
  Message Length: 8 bytes

POSITION-HOLD OPTION

MOTOROLA BINARY FORMAT

ALTITUDE-HOLD HEIGHT PARAMETER

The user can specify receiver height for manual altitude-hold applications. Use of the Altitude-Hold Option enables/disables this application. The altitude-hold height is specified in the units of meters to a resolution of 0.01 meters. The user can reference the height parameter to the GPS reference ellipsoid or to mean sea level. The datum specifying the coordinate system for the altitude-hold height must be the same as the coordinate system specified by the Datum ID currently in use by the GPS Receiver.

Default value: 0 meters

INPUT COMMAND DESCRIPTION:

- Send Current Altitude-Hold Height:

  @@AuxxxxxC<CR><LF>

  xxxxx – $7fffffff (five bytes, hex 7fffffff)
  C – checksum
  Message Length: 12 bytes

- Change Current Altitude-Hold Height:

  @@AuhhhhtC<CR><LF>

  hhhh – height in cm -100000 .. 1,800,000
  (-1000.00 to +18000.00)
  t – height type 0 – GPS ref ellipsoid
  1 – msl height
  C – checksum
  Message Length: 12 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@AuhhhhtC<CR><LF>

  hhhh – height in cm -100000 .. 1,800,000
  (-1000.00 to+18000.00)
  t – height type 0 – GPS ref ellipsoid
  1 – msl height
  C – checksum
  Message Length: 12 bytes

ALTITUDE-HOLD HEIGHT PARAMETER

MOTOROLA BINARY FORMAT

ALTITUDE-HOLD OPTION

The user can specify a height coordinate for altitude-hold applications. This selection allows the user to manually enable or disable the altitude-hold function. Remember, the GPS Receiver automatically holds altitude to the current height when the xDOP is greater than the "3D to 2D DOP Threshold," or when the GPS Receiver is tracking three satellites.

Default value: Disabled

INPUT COMMAND DESCRIPTION:

- Send Current Altitude-Hold Mode:

  @@AvxC<CR><LF>

  x – $ff (one byte, hex ff)
  C – checksum
  Message Length: 8 bytes

- Change Altitude-Hold Mode:

  @@AvmC<CR><LF>

  m – mode — 0 – Disabled, 1 – Enabled

  C – checksum
  Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@AvmC<CR><LF>

  m – mode — 0 – Disabled, 1 – Enabled

  C – checksum
  Message Length: 8 bytes

UTC TIME CORRECTION OPTION

This option selects the type of time to be output in the Position/Status/Data output messages during the Position Fix mode. If a 0 is selected, time outputs are referenced to GPS time. If 1 is selected, time outputs are referenced to Universal Time Coordinated (UTC) time. The GPS Receiver decodes the GPS-to-UTC time offset parameters transmitted by the GPS satellites and automatically applies it if UTC time is selected. The GPS Receiver 1PPS output signal is also referenced to UTC 1 second tic marks or GPS time 1 second tic marks based on the setting of this parameter

Default value: UTC Correction Enabled

INPUT COMMAND DESCRIPTION:

- Send Current UTC Correction Mode:

  @@AwxC<CR><LF>

  x – $ff (one byte, hex ff)
  C – checksum
  Message Length: 8 bytes

- Change UTC Correction Mode:

  @@AwmC<CR><LF>

  m – mode 0 – Disabled
  1 – Enabled

  C – checksum
  Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@AwmC<CR><LF>

  m – mode 0 – Disabled
  1 – Enabled

  C – checksum
  Message Length: 8 bytes

UTC TIME CORRECTION OPTION

MOTOROLA BINARY FORMAT

MEASUREMENT EPOCH OFFSET OPTION

NOTE: The input/output messages described here are available only if GPS Receiver Option A is installed.

The GPS Receiver computes position relative to a measurement epoch that occurs once per second. The GPS Receiver can place the measurement epoch on any of 1,000 1 -millisecond measurement sample points. This 1-millisecond time reference clock is synchronous to the receiver's internal oscillator and is asynchronous to GPS/UTC system time. The user can move the measurement epoch with this command.

At power-up, the GPS Receiver selects a measurement epoch by simply choosing one of the 1,000 1 kHz clocks. This epoch is asynchronous to GPS/UTC time mark. When the GPS Receiver acquires satellites, it will compute a local time of the asynchronous measurement epoch (one of the 1,000 1 kHz clocks), and then skew receiver timing so as to place the measurement epoch within 0.001 seconds of the desired measurement epoch offset. The skew action inserts between 0.000 and 0.999 seconds between measurement epochs so as to move the epoch to the desired sample point. In addition, the GPS Receiver automatically will insert or delete 1 millisecond when necessary to keep the measurement epoch on the selected time because of the receiver local oscillator drift.

As an example, consider the case where the user specifies 0.333 for the Measurement Epoch Offset. For this case, the receiver skews the receiver timing so that the fractional part of local receiver time is 0.333xxxx.... The receiver position output will be relative to this new measurement epoch until this parameter is changed again.

The corrected time reference is relative to either GPS or UTC time, as specified and set by the user via the Time Correction option.

Default: 0.000 seconds
Range: 0.000 to 0.999 seconds
Resolution: 0.001 seconds

INPUT COMMAND DESCRIPTION:

- Send Current Measurement Epoch Offset:

  @@AxxxC<CR><LF>

  xx = $ffff (two bytes, all hex ff)
  C – checksum
  Message Length: 9 bytes

- Change Current Measurement Epoch Offset:

  @@AxttC<CR><LF>

  tt – Time offset in msec 0 .. 999
  (0.000 to 0.999 sec)
  C – checksum
  Message Length: 9 bytes

RESPONSE MESSAGE:

- *(to either command):*

  @@AxttC<CR><LF>

  tt – Time offset in msec 0 .. 999
  (0.000 to 0.999 sec)
  C – checksum
  Message Length: 9 bytes

MEASUREMENT EPOCH OFFSET OPTION

MOTOROLA BINARY FORMAT

1PPS TIME OFFSET OPTION

NOTE: The input/output messages described here are available only if PVT6 GPS Receiver Option A is installed.

The GPS Receiver computes position relative to a measurement epoch that occurs once per second. In addition, the GPS Receiver outputs a one pulse-per-second (1PPS) signal, the rising edge of which is placed on top of the GPS/UTC 1 second tic mark epoch. The 1PPS Time offset allows the user to offset the one-pulse per second time mark in 1 nanosecond increments. The offset is relative to the Measurement Epoch offset.

The corrected time reference is relative to either GPS or UTC time, as specified and set by the user.

The resolution of this parameter is 1 nanosecond. This does not imply that the accuracy of the 1PPS output signal is to this level. The absolute accuracy of the signal is a function of the GPS satellite system, and is subject to denial of accuracy due to U.S. Department of Defense policy.

Default:	0.000 seconds
Range:	0.000000000 to 0.999999999 seconds
Resolution:	1 nanosecond

INPUT COMMAND DESCRIPTION:

- Send Current 1PPS Offset:

  @@AyxxxxC<CR><LF>

  xxxx – $ffffffff (four bytes, all hex ff)
  C – checksum
  Message Length: 11 bytes

- Change Current 1PPS Offset:

  @@AytttC<CR><LF>

  tttt – Time offset in nsec 0.. 999999999
  (0.0 to 0.999999999 sec)
  C – checksum
  Message Length: 11 bytes

RESPONSE MESSAGE:

- *(to either command)*

  @@AyttttC<CR><LF>

  tttt – Time offset in nsec 0.. 999999999
  (0.0 to 0.999999999 sec)
  C – checksum
  Message Length: 11 bytes

IPPS TIME OFFSET OPTION

MOTOROLA BINARY FORMAT

1PPS CABLE DELAY OPTION

NOTE: The input/output messages described here are available only if PVT6 GPS Receiver Option A is installed.

The GPS Receiver outputs a 1PPS signal, the rising edge of which is placed on top of the GPS/UTC 1 second tic mark epoch. The 1PPS Cable Delay offset allows the user to offset the one-pulse per second time mark in 1 nanosecond increments relative to the Measurement Epoch. The Cable Delay allows the user to select between zero and 1 additional millisecond to compensate for the length of the antenna cable.

This parameter instructs the GPS Receiver to output the 1PPS output pulse earlier in time to compensate for antenna cable delay. Up to 1 millisecond of equivalent cable delay can be removed. Zero cable delay is set for a zero-length antenna cable. The user should consult a cable data book for the delay per foot for the particular antenna cable used in order to compute the total cable delay needed for a particular installation.

The corrected time reference is relative to either GPS or UTC time, as specified and set by the user.

Default: 0.000 seconds
Range: 0.000 to 0.000999999 seconds
Resolution: 1 nanosecond

INPUT COMMAND DESCRIPTION:

- Send Current 1PPS Offset:

  @@AzxxxxC<CR><LF>

  xxxx – $ffffffff (four bytes, all hex ff)
  C – checksum
  Message Length: 11 bytes

- Change Current 1PPS offset:

  @@AzttttC<CR><LF>

  tttt – Time offset 0 .. 999999
  res = 1 nsec (0.0 to 0.000999999 sec)
  C – checksum
  Message Length: 11 bytes

RESPONSE MESSAGE:

- *(to either command)*:

  @@AzttttC<CR><LF>

  tttt – Time offset 0 .. 999999
  res = 1 nsec (0.0 to 0.000999999 sec)
  C – checksum
  Message Length: 11 bytes

1PPS CABLE DELAY OPTION

MOTOROLA BINARY FORMAT

EPHEMERIS HOLD OPTION

When this option is disabled, the GPS Receiver automatically acquires and uses the latest satellite ephemeris data set from the GPS satellites. When the GPS Receiver detects a new ephemeris data set, it collects the new data and immediately begins using the new data.

When this option is enabled, the GPS Receiver holds the current ephemeris set in memory and will not collect new ephemeris from the GPS satellites. With ephemeris hold enabled, the GPS Receiver will only accept and use new ephemeris data input via the RS232 port.

Ephemeris Hold Option is always disabled at power-on.

Default: Disabled

INPUT COMMAND DESCRIPTION:

- Send Current Ephemeris Hold Mode:

  @@AAxC<CR><LF>

  x – $ff (one byte, hex ff)
  C – checksum
  Message Length: 8 bytes

- Change Current Ephemeris Hold Mode:

  @@AAmC<CR><LF>

  m – mode 0 – disable
  1 – enable
  C – checksum
  Message Length: 8 bytes

RESPONSE MESSAGE:

- (to either command):

  @@AAmC<CR><LF>

  m – mode 0 – disabled
  1 – enabled
  C – checksum
  Message Length: 8 bytes

APPLICATION TYPE

This option is used to manually change the receiver application type. Setting this parameter allows the user to select optimized search and reacquisition strategies for different receiver applications

Note the initial satellite search time is the time the receiver sends searching for the assumed visible satellites (based on the almanac and initial receiver position). Further note, for all application types, if the set of assumed visible satellites have not been found by the end of the initial search time, the receiver begins a systematic search for all satellites in the GPS constellation.

Application Type	Maximum Expected Velocity	Velocity Averaging	Approximate Initial Satellite Search Time
Air	> 100 m/s	1 sec	15 min
Handheld	< 100 m/s	5 sec	2 min
Land	< 100 m/s	1 sec	30 min
Marine	< 100 m/s	5 sec	2 min
Static	< 100 m/s	1 sec	2 min

INPUT COMMAND DESCRIPTION:

- Send Current Application Type:

  @@ABx<CR><LF>

  x – $ff (one byte, hex ff)
  C – checksum
  Message Length: 8 bytes

- Change Current Application Type:

  @@ABtC<CR><LF>

  t – application type
  - 0 – air
  - 1 – handheld
  - 2 – land
  - 3 – marine
  - 4 – static

  C – checksum
  Message Length: 8 bytes

RESPONSE MESSAGE:

- (to either command):

  @@ABtC<CR><LF>

  t – application type
  - 0 – air
  - 1 – handheld
  - 2 – land
  - 3 – marine
  - 4 – static

  C – checksum
  Message Length: 8 bytes

APPLICATION TYPE

MOTOROLA BINARY FORMAT

CORRECTION THRESHOLDS

This command allows the control of two timer thresholds that effect:

1. the "smoothness" of the position fix (FIX_THR)

2. the "smoothness" of the differential correction output (OUT_THR).

The PVT6 GPS Receiver filters the noisy raw code phase measurements with the very smooth carrier phase measurements. This filtering process begins as soon as the signal is acquired and contains as long as the signal is tracked. the filter bandwidth is narrowed gradually and reaches its final state after 128 seconds. The PVT keeps a filter timer for each channel to control the timing of the bandwidth changes. The filter bandwidth is reset to its initial wide setting and the timer set to 0 whenever the signal is lost.

The user-controllable threshold FIX_THR can be used to gate a channel's output of differential corrections until it has had some user-defined adequate time to filter the raw code phase. Earlier versions of PVT6 software used 32 as an internal threshold for this parameter.

There is an inherent interdependence in the use of these two thresholds. For instance, if FIX_THR is set to 16 and OUT_THR is set to 8, then the receiver will filter the raw code phase for 16 seconds before using that channel for fix and then will immediately output differential corrections for that channel (if the message has been requested). The 8 second OUT_THR threshold is effectively overridden by the 16 second FIX_THR threshold in this example.

INPUT COMMAND DESCRIPTION:

- Send Correction Thresholds:

  @@ADxxC<CR><LF>

  x – $ff (one byte, hex ff)
  C – checksum
  Message Length: 9 bytes

- Change Correction Thresholds:

  @@ADfdC<CR><LF>

  t – FIX_THR 0–127 secs
  t – OUT_THR 0–127 secs
  C – checksum
  Message Length: 9 bytes

RESPONSE MESSAGE:

- (to either command):

  @@ADfdC<CR><LF>

  t – FIX_THR 0–127 secs
  t – OUT_THR 0–127 secs
  C – checksum
  Message Length: 8 bytes

CORRECTION THRESHOLDS

MOTOROLA BINARY FORMAT

POSITION/STATUS/DATA OUTPUT MESSAGE

This parameter determines the rate position/ status/data information (Response Message) in output. The input mode parameter (m) instructs the GPS Receiver to either output this message onetime (polled), or to output this message at the indicated update rate (continuously). Once the GPS Receiver is set to continuous output, the continuous message flow can be stopped by sending a one-time output request. The GPS Receiver will output the message one more time, then terminate any further message outputs. The state of the mode bit is stored in nonvolatile memory. If the GPS Receiver was continuously outputing the position/status/data output when turned off, it will begin to output this message continuously (at the selected update rate) again when power is reapplied.

If the GPS Receiver has its Idle Mode option enabled, this parameter selection does not exist, and the GPS Receiver outputs the last known valid position/status/data message once when polled.

INPUT COMMAND DESCRIPTION:

- Set response message rate:

@@BamC<CR><LF>

m – mode	0 – both response messages output once (polled) 1..255 – response message output at indicated rate (continuous) 1 – once per second 2 – once every two sec 225 – once every 255 sec
C – checksum	
Message Length: 8 bytes	

RESPONSE MESSAGE:

- *(to command)*

@@Bamdyyhmsffffaaaaoooohhhhm
mmmvvhhddtntimsdimsdimsdimsd
imsdimsdsC<CR><LF>

Date	
m – month	1 .. 12
d – day	1 .. 31
yy – year	1900 .. 2079
Time	
h – hours	0 .. 23
m – minutes	0 .. 59
s – seconds	0 .. 60
ffff – fractional sec	0 .. 999,999,999 (0.0 to 0.999999999)
Position	
aaaa – latitude in msec	-324,000,000 .. 324,000,000 (-90° to +90°)
oooo – longitude in msec	-648,000,000 .. 648,000,000 (-180° to +180°)
hhhh – height in cm (GPS, ref ellipsoid)	-100000 .. -1,800,000 (-1000.00 to +18000.00 meters)
mmmm – height in cm (msl ref)	-100000 .. 1,800,00 (-1000.00 to +18000.00 meters)
Velocity	
vv – velocity in cm/sec	0 .. 51400 (0 to 514.00 m/sec)
hh – heading (true north. res 0.1°)	0 .. 3599 (0.0 to 359.9 deg)

Note: 1 degree of position equals 3,600 sec or 3,600,000 msec.

GPS receiver reported height is limited to 18,000 meters, and velocity output is limited to 514.0 m/sec by United States export laws. If the GPS Receiver is used above these limits, the height and velocity outputs are clamped to the maximum values. In addition, the latitude and longitude data will be incorrect.

RESPONSE MESSAGE (CONT):

Geometry
- dd – current DOP: 0, 0 .. 999 (0.0 to 99.9 DOP)
- (0.1 res): (0 – not computable), or position-hold, or position prop)
- t – DOP type: 0 – PDOP (in 3D mode); 1 – HDOP (in 2D mode)

Satellite visibility and tracking status
- n – num of visible sat: 0 .. 12
- t – num of sat tracked: 0 .. 6

For each of six receiver channels
- i – sat ID: 0 .. 37
- m – channel tracking mode: 0 .. 8
  - 0 – Code Search
  - 1 – Code Acquire
  - 2 – AGC Set
  - 3 – Freq Acquire
  - 4 – Bit Sync Detect
  - 5 – Message Sync Detect
  - 6 – Satellite Time Avail
  - 7 – Ephemeris Acquire
  - 8 – Avail for Position
- s – Signal Strength: 0 .. 255 (number proportional to SNR)
- d – Channel Status Flag
  Each bit represents one of the following:
  - (msb) Bit 7: Using for Position Fix
  - Bit 6: Satellite Momentum Alert Flag Set
  - Bit 5: Satellite Anti-Spoof Flag Set
  - Bit 4: Satellite Reported Unhealthy
  - Bit 3: Satellite Reported Inaccurate (>16 meters)
  - Bit 2: Spare
  - Bit 1: Spare
  - (lsb) Bit 0: Parity Error

  (End of Channel Dependent Data)
- s – Receiver Status Message-
  - (msb) Bit 7: Position Propagate mode
  - Bit 6: Poor Geometry (DOP > 20)
  - Bit 5: 3D fix
  - Bit 4: Altitude Hold (2D fix)
  - Bit 3: Acquiring Satellites/Position Hold
  - Bit 2: Differential
  - Bit 1: Insufficient visible satellites (< 3)
  - (lsb) Bit 0: Bad Almanac
- C – checksum

Message Length: 68 bytes

POSITION/STATUS/DATA OUTPUT MESSAGE

MOTOROLA BINARY FORMAT

VISIBLE SATELLITE STATUS MESSAGE

This command requests the results of the most current satellite alert computation. The response message gives a summary of the satellite visibility status showing the number of visible satellites, the Doppler frequency and location of the currently visible satellites (up to 12 satellites).

The reference position for the most recent satellite alert is the current position coordinates. Note that these coordinates may not compare to the GPS Receiver's actual position when initially turned on, as the GPS Receiver may have moved a great distance since it was last used.

INPUT COMMAND DESCRIPTION:

- Request Visible Satellite Status:

@@BbmC<CR><LF>

m – mode
- 0 – output response message once (polled)
- 1 – output response message when visibility data changes

C – checksum
Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to command)*

@@Bbniddeaasiddeaasiddeaasi

xDOP TABLE STATUS MESSAGE

This command requests the xDOP parameters corresponding to combinations of currently visible satellites based on the latest satellite visibility calculation. The GPS Receiver will send up to nine combinations of satellites with the corresponding xDOP parameter. The type of DOP is defined by the xDOP Type parameter, and the GPS Receiver will compute xDOP of all combinations of satellites taken six at a time (GPS Receiver is selected for N-in-View Position Fix mode) or for all satellites taken four at a time (GPS Receiver is selected for Best-4 Position Fix mode).

INPUT COMMAND DESCRIPTION:

- Request xDOP Table Status:

@@BcmC<CR><LF>

m – mode
- 0 – output response message once (polled)
- 1 – output response message when data changes (continuous)

C – checksum

Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to command)*

@@Bctnmddsssssssddsssssssddsssssss

ALMANAC STATUS MESSAGE

This command requests the almanac status information corresponding to the currently used satellite almanac data (in RAM), as well as the almanac data currently stored in receiver nonvolatile memory (EEPROM). The GPS Receiver captures a new almanac to internal RAM first and uses this data immediately to compute satellite visibility information. The receiver also copies the RAM data to nonvolatile EEPROM using a slow background process. Consequently, there is a delay between the receipt of a new almanac and copying the new one to EEPROM. The user is given status information on both almanac data sets.

INPUT COMMAND DESCRIPTION:

- Request Almanac Status Command:

@@BdmC<CR><LF>

m – mode
- 0 – Output status once (polled)
- 1 – Output status when RAM almanac data changes (continuous)

C – checksum

Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to command):*

@@BdvwtassssvwtassssC<CR><LF>

RAM Almanac Status –

v – Almanac valid flag	0 – no almanac in receiver 1 – valid almanac in receiver
w – almanac week number (raw)	0 .. 255 (ICD-GPS-200 Ref)
t – time of almanac (raw)	0 .. 147 (ICD-GPS-200 Ref)
a – number of avail sats	0 .. 32
ssss – sat IDs in almanac Each bit represents one SVID (msb = SVID 32; lsb = SVID 1)	32 bit binary field, 0 – SV not available 1 – SV included

EEPROM Almanac Status –

v – almanac valid flag	0 – no almanac in receiver 1 – valid almanac in receiver
w – almanac week number (raw)	0 .. 255 (ICD-GPS-200 Ref)
t – time of almanac (raw)	0 .. 147 (ICD-GPS-200 Ref)
a – number of avail sats	0 .. 32
ssss – sat IDs in Almanac 32 bit binary field, each bit represents one SVID (msb = SVID 32, lsb = SVID 1)	0 – SV not available 1 – SV included

C – checksum

Message Length: 23 bytes

ALMANAC STATUS MESSAGE

MOTOROLA BINARY FORMAT

ALMANAC DATA OUTPUT MESSAGE

This parameter determines the rate the almanac data is output. The user has the option of requesting the almanac data output one time (polled), or each time the almanac data changes (continuously). The almanac data output parameter set is stored in nonvolatile memory.

Almanac data for the GPS satellites is transmitted in words 3 through 10 of subframe 5 (pages 1 through 25), and words 3 through 10 of subframe 4 (pages 2 through 5, 7 through 10, and 25) of the satellite broadcast data message. The user is directed to ICD-GPS-200 for specifics on the format of the almanac data.

The GPS Receiver outputs the almanac data through a series of output messages, each of which is identified by the particular subframe and page. The data fields of each individual message corresponds to words 3 through 10 of the broadcast data. Each word contains 24 data bits.

The entire almanac data output consists of 34 output response messages corresponding to the 25 pages of subframe 5 and the 9 pages in subframe 4 that contain almanac data (pages 2 through 5, 7 through 10, and 25). The total message output for one output request is 1122 bytes including the @@Be prefix and the checksum / carriage return / line feed for each output. The output message begins with subframe 5 page 1.

The GPS Receiver will output about 750 bytes of message data for each 1 second output opportunity. If selected, the almanac response message is output until the total number of bytes sent on a 1-second epoch exceeds 750. The remainder of the almanac message is sent on the next 1-second epoch (up to the 750 byte limit per second) until all of the almanac data is output.

If the user issues this command and the GPS Receiver does not contain an almanac, then the GPS Receiver returns one response message with the subframe and page bytes equal to zero.

INPUT COMMAND DESCRIPTION:

- Set Almanac Data Output Rate:

@@BemC<CR><LF>

m – mode 0 – output response message once (polled)
1 – output response message when almanac data changes (continuous)

C – checksum
Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to command)*

@@Cbspxxxxx...xxxxC<CR><LF>

sp – subframe/page Number sf 5 / pgs 1 – 25
or
sf 4 / pgs 2 – 5, 7 – 10, 25
xxx....xxx Words 3 - 10, each word is 3 bytes long (format per ICD-GPS-200)
C – checksum
Message Length: 33 bytes

NOTE: If no almanac is present in GPS Receiver, then the receiver returns one output response message with the "sp" field set to 0, and all other bytes in the field set to 0.

ALMANAC DATA OUTPUT MESSAGE

MOTOROLA BINARY FORMAT

EPHEMERIS DATA OUTPUT MESSAGE

This parameter determines the rate satellite ephemeris data is output. The user has the option of requesting the ephemeris data output one time (polled), or each time the satellite ephemeris data changes (continuously). The GPS Receiver remembers the last rate of the satellite ephemeris data output (with 5/12V_BATT signal applied) when turned off.

Ephemeris data for each of the GPS satellites is contained in subframes 1, 2, and 3, words 3 through 10. Each satellite transmits the ephemeris data for itself only. The user is directed to ICD-GPS-200 for specifics on the format of the ephemeris data.

When polled, the GPS Receiver outputs a complete Ephemeris Data Output Message for each of the satellites that the receiver is currently using for position fix, up to six satellites. When requested continuously, the GPS Receiver outputs the current ephemeris once for all satellites currently tracked, then outputs individual channel ephemeris again any time the ephemeris on that channel changes.

The GPS Receiver outputs the ephemeris data through a series of output messages, each of which corresponds to a particular satellite. The data fields of each message corresponds to words 3 through 10 of subframes 1 through 3. Each word contains 24 data bits.

The GPS Receiver will output about 750 bytes of message data for each 1-second output opportunity. If selected, the ephemeris response message is output for each satellite that is currently tracked (up to six) until the total number of bytes sent on a 1-second epoch exceeds 750. The remainder of the ephemeris message is sent on the next 1-second epoch (up to the 750 byte limit per second) until all of the ephemeris data for all satellites is output.

INPUT COMMAND DESCRIPTION:

- Set Response Message Rate:

@@BimC<CR><LF>

m – mode — 0 – output response message once (polled)
1 – output response message when ephemeris data changes (continuous)

C – checksum
Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to command)*:

@@Bfixxxxx...xxxxC<CR><LF>

i – Sat ID — 1 .. 37
xxx ... xxx - Ephemeris — sf 1 – 3 / words 3 – 10 (72 bytes per sat; format ICD-GPS-200)

C – checksum
Message Length: 80 bytes

Note: The GPS Receiver returns one output response message for each of up to six currently tracked satellites. For example, if the GPS Receiver is currently tracking five satellites, five output response messages will be sent by the receiver, one for each satellite.

EPHEMERIS DATA OUTPUT MESSAGE

MOTOROLA BINARY FORMAT

SATELLITE RANGE DATA OUTPUT MESSAGE

NOTE: The input/output messages described here are available only if GPS Receiver Options C, D, or E are installed.

This parameter determines the rate basic satellite range and range-rate information for each of the satellites that the GPS Receiver is tracking is output. The user has the option of requesting the satellite range data status one time (polled), or continuously at a user specified update rate. The selected rate is stored in the GPS Receiver's non-volatile memory.

INPUT COMMAND DESCRIPTION:

- Set response message rate:

  @@BgmC<CR><LF>

  m – mode 0 – Output response message once (polled)
  1 .. 255 – Output response message at indicated rate (continuous)
  1 – output message once per sec
  2 – output message one time every 2 seconds

  C – checksum
  Message Length: 8 bytes

In the discussions that follow, the subscript ($_k$) refers to the current measurement data, and the subscript (k-1) refers to the previous (1 second old) data.

The user can convert the above message into pseudorange and pseudorange rate for each satellite by the following formulas:

Pseudorange (in meters) = (GPS local time – GPS satellite time) * SOL

Note: Not corrected for possible End-Of-Week rollovers.

Pseudorange rate (in meters per second) = K2 * (ICP_k – ICP_{k-1})

ICP is the integer and fractional part of ICP treated as a 32 bit unsigned quantity. Use 32 bit unsigned integer subtraction to avoid rollovers.

Absolute carrier phase at measurement epoch in degrees = K4 * ICP_f

A bit in each of the channel tracking mode words of the response message is used to denote whether or not the channel has lost carrier lock since the last output of this message. This information is helpful for users who perform post-processing and it eliminates the need to output this message at a one second rate.

If the GPS Receiver has its Idle mode option enabled, this parameter selection does not exist, and the GPS Receiver outputs the last known valid Range Data Output information once when polled.

RESPONSE MESSAGE:

- *(to command)*

  OPTION C:

  @@Bgttfffffimsssffffccffrrrd
  dimsssffffccffrrrddimsssffff
  ccffrrrddimsssffffccffrrrddi
  msssffffccffrrrddimsssffffcc
  ffrrrddC<CR><LF>

  OPTION D:

  @@Bgttfffffimsssffff0000rrrd
  dimsssffff0000rrrddimsssffff
  0000rrrddimsssffff0000rrrddi
  msssffff0000rrrddimsssffff00
  00rrrddC<CR><LF>

  OPTION E:

  @@Bgttfffffim00000000000rrrd
  dim00000000000rrrddim0000000
  0000rrrddim00000000000rrrddi
  m00000000000rrrddim000000000
  00rrrddC<CR><LF>

Length:	122 bytes
ttt – GPS local time in sec	0 .. 604799
ffff – GPS local fractional time in ns	0 ..0.999999999
resolution – 1 nsec	(0 .. 0.999999999)

INPUT COMMAND DESCRIPTION (CONT):

The GPS satellite time used in the first equations for the computation of pseudorange is the same value that the PVT6 uses internally. This satellite time value combines code and carrier information and has been pre-smoothed using carrier aided filtering with a very narrowband (0.005 Hz) lowpass filter algorithm. The user has access to the unfiltered raw code phase via the following:

Raw Code Phase (in meters) = K1 * RCP – K2 * ICP_f + K3 * K5 * CD

where

RCP is the raw code phase from the message

ICP_f is the fractional part of integrated carrier phase in message.

CD is the code discriminator output from the message.

K5 = A variable code discriminator calibration constant. (see below)

Code discriminator calibration constant: When tracking satellites, the receiver causes the raw code phase to move back and forth once per second in discrete steps of 1 code phase quantum. One code phase quantum is equal to 55 carrier cycles, or about 10.4662 meters. This intentional dither allows the receiver to calibrate the output of the code discriminator.

The user can accurately calibrate the code discriminator output by using the fact that the long term average difference between subsequent code discriminator measurements will be equal to 1 quantum, or 10.4662 meters. K5, the calibration constant, varies slowly over time as a function of received signal to noise ratio and multipath. Typical values of K5 are between 0.5 < K5 1.5. A simple lowpass filter can be used to generate K5 as follows:

diff = K3 * abs ($CD_{k - CDk-1}$)

$CD_{k-1 = CDk}$

LPF = LPF + beta * (diff - LPF) (initialize LPF = 10.4662 meters)

K5 = 10.4662 / LPF

The constant "beta" establishes the filter time constant. Typical values of beta are 0.001 (maximum filtering) to 0.5 (minimum filtering). The PVT6 uses a constant of 0.05 internally.

OTHER FIXED CONSTANTS:

L1F0 = 1,575,420,000.0 Hz (L1 carrier frequency)

SOL = 299,792,458.0 meters/sec (GPS value of speed of light)

K1 = SOL / L1F0

K2 = K1 / 65536

K3 = (2^{-11}) * SOL * 0.001 / 28644

K4 = 360 / 65536

RESPONSE MESSAGE (CONT):

For each Channel:

i – satellite ID — 0 .. 32
0 – channel not used
1-32 – sat ID

m – channel tracking mode
where bits 0–3 are decoded as
0 – code search
1 – code acquire
2 – AGC set
3 – frequency acquire
4 – bit sync detect
5 – message sync detect
6 – sat time avail
7 – ephemeris acquire
8 – avail for position fix

and where bit 7 (i.e., the MSB) is decoded as
0 – carrier locked since last range message
1 – carrier locked since last sat range message

sssffff – GPS satellite time (Integrated Carrier Phase Filtered)
sss – integer part — 0 .. 604799
resolution – 1 sec
ffff – fractional part — 0 .. 999999999
resolution – 1 nsec — (0 .. 0.999999999)

ccff – integrated carrier phase
cc – integer part — 0 .. 65535
16 MS bits of carrier phase (above decimal point) — (cycles)
ff – fractional part — 0 .. 65535
16 bits of carrier NCO below decimal point at measurement epoch — (0 .. 59.9945 degrees)

rrr – raw code phase (carrier cycles) — 0 .. 1575420

dd – code discriminator output at measurement epoch — -32768 .. 32767
LSB = (2^{-12})*SOL*0.001/28644 meters

C – checksum

Message Length: 122 bytes

SATELLITE RANGE DATA OUTPUT MESSAGE

MOTOROLA BINARY FORMAT

OUTPUT PSEUDORANGE CORRECTION OUTPUT MESSAGE

NOTE: The input/output messages described here are available only if GPS Receiver Option B is installed.

This parameter sets the rate the pseudorange correction status is output from the GPS Receiver.

The pseudorange correction response message allows the GPS Receiver to be used as a master site receiver in a real-time differential system. The message is structured to return a pseudorange and pseudorange rate correction for each of the six receiver channels, and identifies the satellite ID that corresponds for each channel. To use this output properly, the GPS Receiver must have the position-hold option enabled, with the current GPS Receiver position entered into the position-hold-position coordinates. The assignment of satellites to channels is accomplished during normal receiver operation, or may be done either manually or automatically.

If the GPS Receiver is in the Idle mode, the GPS Receiver outputs the last known valid Pseudorange Correction response message only when polled.

INPUT COMMAND DESCRIPTION:

- Set response rate:

@@BhmC<CR><LF>

m – mode (polled)
- 0 – output response message once
- 1..255 – output response message at indicated rate (continuous)
  - 1 – output message once per sec
  - 2 – output message once every 2 sec
  - 255 – output message once every 255 sec

C – checksum

Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to command)*

@@CetttippprrdippprrdippprrdippprrdippprrdippprrdC<CR><LF>

ttt – GPS time ref	0 .. 6047999 (0.0 .. 604799.9)
i – Satellite ID	0..32 0 = not used 1-32 = sat ID
ppp – pseudorange correction 0.01 meter resolution	-1,048,576 .. +1,048,576 (-10485.76 ..+10485.76)
rr – pseudorange rate correction 0.001 m/s resolution	-4096 .. 4096 (-4.096 .. 4.096)
d – issue of data emphemeris	0 .. 255

C – checksum

Message Length: 52 bytes

LEAP SECOND PENDING STATUS MESSAGE

This command causes the receiver to send a message to the user indicating the status of any pending leap second correction to UTC time due at the end of the current month. If a leap second correction is pending,the direction of the correction is also indicated. This is a polled-only output message.

Leap seconds are occasionally inserted in UTC time and generally occur on midnight UTC June 30 or midnight UTC December 31. The GPS control segment notifies GPS users of pending leap second insertions to UTC time several weeks before the event via a special broadcast message in the satellite downlink message. The receiver decodes this data and then inserts the time correction in the appropriate 1 second time bin.

INPUT COMMAND DESCRIPTION:

@@BjC<CR><LF>

C – checksum
Message Length: 7 bytes

RESPONSE MESSAGE:

@@BjmC<CR><LF>

m – message 0 – No leap second pending
1 – Addition of 1 second pending
2 – Subtraction of 1 second pending
C – checksum
Message Length: 8 bytes

LEAP SECOND PENDING STATUS MESSAGE

MOTOROLA BINARY FORMAT

SELF-TEST

The GPS Receiver user has the ability to initiate an extensive self-test. The tests that are accomplished during the commanded self-test are as follows:

ROM checksum
RAM
EEPROM
Correlator IC
SPI port comm with DCXO
SPI port comm with RTC and Time increment
SCI comm is verified operational if the RS232 port is active

The output of the self-test command is a 16-bit field, where each bit of the field represents the go/no-go condition of the particular item tested.

INPUT COMMAND DESCRIPTION:

- Initiates Self-Test:

  @@CaC<CR><LF>

  C – checksum
  Message Length: 7 bytes

RESPONSE MESSAGE:

- *(to command)*

  @@CaxxC<CR><LF>

  xx – self test result

Each bit of the self-test result field is either zero (pass) or one (fail) and represents the result of the following tests:

(msb)	Bit 15:	Spare
	Bit 14:	Spare
	Bit 13:	RTC Comm & Time
	Bit 12:	DCXO SPI Comm
	Bit 11:	EEPROM
	Bit 10:	RAM MSByte
	Bit 9:	RAM LSByte
	Bit 8:	ROM MSByte Checksum
	Bit 7:	ROM LSByte Checksum
	Bit 6:	1 KHz Presence
	Bit 5:	Channel 6 Correlation test
	Bit 4:	Chennel 5 Correlation test
	Bit 3:	Channel 4 Correlation test
	Bit 2:	Channel 3 Correlation test
	Bit 1:	Channel 2 Correlation test
(lsb)	Bit 0:	Channel 1 Correlation test

C – checksum
Message Length: 9 bytes

SELF-TEST

MOTOROLA BINARY FORMAT

INPUT ALMANAC DATA

This input data utility command installs an almanac into the receiver's nonvolatile memory. This command will cause the GPS Receiver to accept an almanac data file via its RS232 port. The entire almanac data message consists of 34 unique formatted messages that correspond to the subframe and page number of the almanac data (see GPS-ICD-200 for format description).

The GPS Receiver echoes the input almanac data subframe and page numbers of messages received so the user can validate that each almanac slice has been accepted. The PVT6 GPS Receiver will collect an entire almanac in local storage, then check the almanac for validity. The receiver will update the internal almanac data with the new user-supplied almanac upon completion of the receipt of a valid almanac.

Upon completion of the receipt of a valid almanac, the GPS Receiver outputs an almanac status message (see Almanac Status). This output verifies that the almanac was accepted and is currently being used for satellite visibility and DOP computations. Upon completion of the storage of the new almanac to nonvolatile memory (EEPROM), the GPS Receiver will output another almanac status message to verify successful storage of the almanac.

Any single input message that has an invalid subframe (i.e., not 4 or 5) will reset the almanac collection software so that the local collection of almanac data can begin fresh. Subframe 5 page 1 marks the beginning message and resets the collection process. The data for subframe 5 page 1 must appear first in the string of 34 commands that make up the total almanac input data. Order for the remaining data is not important.

At 9600 baud, the user can insert up to about 1K of data per second into the RS232 port. Consequently, the user should be aware that the 34 total messages that make up the almanac data will take longer than 1 second to input into the receiver. Also, the output response message to each input is limited by the 750 maximum byte transfers per second. As a result, the GPS Receiver will take several seconds to operate on all 34 input almanac data commands.

If the GPS Receiver currently is storing an almanac when the user inputs another almanac, the GPS Receiver will complete the storage of the first almanac to nonvolatile memory before accepting the new user input almanac.

INPUT COMMAND DESCRIPTION:

@@Cbspxxx...xxxc<CR><LF>

sp – Subframe/ Page Number	sf 5 / pgs 1 – 25 or sf 4 / pgs 2 – 5, 7 – 10, 25
xxx....xxx	words 3 – 10, each word is bytes long (Format per ICD-GPS-200)

C – checksum

Message Length: 33 bytes

RESPONSE MESSAGE:

- (to each of 34 commands):

@@Chspc<CR><LF>

sp – Subframe/Page Number	sf 5 / pgs 1 – 25 or sf 4 / pgs 2 – 5, 7 – 10, 25

C – checksum

Message Length: 9 bytes

INPUT ALMANAC DATA

MOTOROLA BINARY FORMAT

INPUT EPHEMERIS DATA

This command will cause the receiver to accept satellite ephemeris data input via the RS-232 port. The receiver keeps the ephemeris decoded from all satellites in its nonvolatile memory as long as the 5/12V_BATT voltage is applied to the receiver, and the ephemeris is still valid (t-toe < 4 hours). However, the ephemeris that the user inputs via the RS-232 port is only remembered until the next time the receiver power is cycled, or until it is replaced as a normal part of decoding new ephemeris data from a satellite. This is true even though the 5/12V_BATT voltage may have been applied during the receiver off period. The ephemeris-hold switch can be used to prevent the receiver from replacing the user input ephemeris with new data decoded from the satellites.

The input format is identical to the format output by the receiver for the output ephemeris command to allow the same ephemeris output file to be used by the receiver for an ephemeris input file.

The receiver echoes the input ephemeris data format message so the user can validate that the ephemeris data with the new user supplied ephemeris upon completion of the receipt of a valid ephemeris.

INPUT COMMAND DESCRIPTION:

- Input satellite ephemeris data:

@@Bfixxx...xxxc<CR><LF>

i – sat ID 1 .. 37
xxx ... xxx ephemeris sf 1 – 3/words 3 – 10
(72 bytes per sat;
format per ICD-GPS-200)
C – checksum
Message Length: 80 bytes

RESPONSE MESSAGE:

- *(to command)*

@@Ccixxx...xxxc<CR><LF>

i – Sat ID 1 .. 37
xxx ... xxx ephemeris sf 1 – 3/words 3 – 10
(72 bytes per sat;
format per ICD-GPS-200)
C – checksum
Message Length: 80 bytes

INPUT EPHEMERIS DATA

MOTOROLA BINARY FORMAT

POSITION/STATUS/DATA EXTENSION MESSAGE

This message contains information that can be considered to be an extension of the data output in the POSITION/STATUS/DATA message (@@Ba). Some users may have applications requiring use of this data at the same rate as the POSITION/STATUS/DATA message while other users may only need portions of this data at a much slower rate (e.g., magnetic variation).

Magnetic variation can be used to correct the true north heading (see POSITION/STATUS/DATA MESSAGE) to magnetic north. The correction is computed using an algorithm developed by the U.S. Naval Oceanographic Office. It is based on the WMM-90 (World Magnetic Model 1990) magnetic field model which was generated from actual field measurements and is valid until January 1, 1995. Another table will be available from the U.S. Defense Mapping Agency (DMA) at that time. The algorithm characterizes primarily that portion of the Earth's magnetic field which is generated by the Earth's conducting fluid outer core. Portions of the geomagnetic field generated by the Earth's crust, mantle, ionosphere, and magnetosphere are for the most part not represented in these models. Consequently, a magnetic sensor such as a compass or magnetometer may observe spatial and temporal magnetic anomalies when referenced to the appropriate World Magnetic Model. In particular, certain local, regional, and temporal magnetic declination anomalies can exceed 10 degrees. Anomalies of this magnitude are not common, but they do exist. Declination anomalies on the order of 2 or 3 degrees are not uncommon, but are of small spatial extent and relatively isolated. From a global perspective, the root-mean-square (RMS) error at sea level of the World Magnetic Model are estimated to be less than 1.0 degrees over the entire 5-year life of the model.

INPUT COMMAND DESCRIPTION:

- Request extension message:

@@BkmC<CR><LF>

m – mode
- 0 – output response message once (polled)
- 1 .. 255 – output response message at indicated rate (continuous)
- 1 – once per second
- 2 – once every two seconds
- 255 – once every 255 seconds

C – checksum

Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to command)*:

@@Bkggpphhvvttmmnneeuuaaxxxx
yyyyzzzzrrrrriiiiiiiiiiiiii
iiiiccooC<CR><LF>

Note: DOP values are NOT valid if in position hold mode.

current GDOP

gg – 0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 only valid if in 3D Fix mode)

RESPONSE MESSAGE (CONT):

current PDOP
- pp – 0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 only valid if in 3D Fix mode)

current HDOP
- hh – 0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 only valid if in 2D or 3D Fix mode)

current VDOP
- vv – 0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 only valid if in 3D Fix mode)

current TDOP
- gg – 0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 only valid if tracking at least one satellite)

magnetic variation
- mm – –1800 to +1800 (–180.0 to +180.0 degrees) resolution = 0.1
  - positive angles are east
  - negative angles are west

velocity in north, east, up coordinate system
- nn – north – 32767 to 32767 (m/sec) resolution = 0.1)
- ee – east – 32767 to 32767 (m/sec) resolution = 0.1)
- uu – up – 32767 to 32767 (m/sec) resolution = 0.1)

RESPONSE MESSAGE (CONT):

age of differential correction data (for slave receiver)
- aa – 0 to 65535 (secs) resolution 0.1

receiver position in ECEF coordinate system (X, Y, Z) in meters
- xxxx – resolution = 0.1 meters
- yyyy – resolution = 0.1 meters
- zzzz – resolution = 0.1 meters

URA for each of six receiver channels
- r – as decoded from the GPS satellite message (0–15 is valid URA, =63 if not decoded yet) see NAVSTAR ICD-GPS-200 Section 20.3.3.3.1.3

Least Squares A^{-1} Symmetrical Matrix element (10 elements)
- ii – A^{-1} Matrix element where
  - element #1 is $A^{-1}[0][0]$
  - element #2 is $A^{-1}[0][1]$
  - element #3 is $A^{-1}[0][2]$
  - element #4 is $A^{-1}[0][3]$
  - element #5 is $A^{-1}[1][1]$
  - element #6 is $A^{-1}[1][2]$
  - element #7 is $A^{-1}[1][3]$
  - element #8 is $A^{-1}[2][2]$
  - element #9 is $A^{-1}[2][3]$
  - element #10 is $A^{-1}[3][3]$
  - resolution = 0.1 (unitless)

receiver clock bias
- cc – –32767 to +32767 (in meters) resolution = 0.1

receiver oscillator offset
- oo – 0 to 65535 (in m/sec) resolution = 0.1

C – checksum

Message Length: 69 bytes

POSITION/STATUS/DATA EXTENSION MESSAGE

MOTOROLA BINARY FORMAT

ALERT-PLANNING

This utility command allows the user to compute satellite visibility information for other locations than the GPS Receiver's current location. This can be accomplished in either the Idle or the Position Fix modes. The input command allows the user to specify the date, time, location, satellite mask angle, and GMT time correction to compute the satellite visibility information, and the output response message returns satellite elevation, azimuth, and Doppler information for up to 12 visible satellites as well as DOP vs satellite selection combinations for up to 9 different combinations. The receiver uses the current datum ID, Satellite Ignore List, Position Fix Algorithm Type, and xDOP Computation Type parameters in order to compute the Alert Plan.

The time the GPS Receiver requires to compute the output response message is a function of the current loading on the PVT6 GPS Receiver CPU. The response message will be output much faster if the GPS Receiver is placed in the Idle mode before the input command string is entered. Otherwise, the output message is made available when there is sufficient time for the GPS Receiver to process the input command and compute the output visibility data. The user can build a visibility vs time table by inputting alert request commands, one at a time, that increase the time parameter at some constant rate (i.e., every 15 minutes).

INPUT COMMAND DESCRIPTION:

- Initiate Alert-Planning:

@@Cdmdyyhmsggaaaaoooohhmc
<CR><LF>

Date
- m – month 1..12
- d – day 1..31
- yy – year 0000 .. 2079

Time-
- h – hours 0 .. 23
- m – minutes 0 .. 59

GMT Correction-
- s – sign of GMT corr 00 – positive; ff – negative
- gg – GMT Corr (hrs,min)
  - hrs: 0 .. 12
  - min: 0 .. 59

Position-
- aaaa – latitude in msec -324000000..324000000 (-90° - +90°)
- oooo – longitude in msec -648000000..648000000 (-180° – +180°)
- hh – height in meters -1000 .. 18000

Satellite Mask Angle –
- m – Sat Mask Angle in deg 0 .. 89

C – checksum

Message Length: 27 bytes

Note: The response message to an alert-planning command with at least one out-of-range input parameter is to return all fields of the above response message zero-filled. In addition, the response is zero filled when no almanac is present in the PVT6 GPS Receiver.

RESPONSE MESSAGE:

- *(to command)*

@@Cdmdyyhmniddeaasiddeaasidd
eaasiddeaasiddeaasiddeaasidd
eaasiddeaasiddeaasiddeaasidd
eaasiddeaastddssssssddssssss
ddssssssddssssssddssssssddss
ssssddssssssddssssssddssssss
c<CR><LF>

Date –
- m – month 1..12
- d – day 1..31
- yy – year 1980 .. 2079

Time –
- h – hours 0 .. 23
- m – minutes 0 .. 59

Sat Visibility Info –
- n – number of visible sats 0 .. 12
  (for each visible sat, up to n fields contain valid data)
- i – satellite PN code ID 1 .. 32
- dd – Doppler in Hz -5000 .. 5000
- e – elevation (degrees) 0 .. 90
- aa – Azimuth (degrees) 0 .. 359
- s – sat health 0 – healthy; 1 – removed from sv sel; 2 – unhealthy

xDOP vs Satellite Selection Info (up to 9 combinations) –
- t – xDOP type 0 – GDOP; 1 – PDOP; 2 – HDOP; 3 – VDOP; 4 – TDOP
- dd – DOP (0.1 resolution) 0,10 .. 999 (0,1.0 .. 99.9) dd = 0 if the combination is not valid
- ssssss – SVID per chan each s = 0 .. 32 for sat ID (zero indicates chan not used)

C – checksum

Message Length: 171 bytes

INPUT PSEUDORANGE CORRECTION

NOTE: The input/output messages described here are available only if GPS Receiver Option B is installed.

Enabling this option allows the GPS Receiver to accept pseudorange correction messages from a differential master site receiver. The input message is structured to accept pseudorange and pseudorange-rate corrections for up to six satellites. The slave receiver uses the corrections in the input message by associating the satellite ID with the corresponding satellite (channel) that the slave is tracking. The user can specify up to 12 satellite corrections through the use of two back-to-back input commands.

INPUT COMMAND DESCRIPTION:

- Enable Pseudorange Correction (for up to six sat):

@@Cetttippprrdippprrdippprrd
ippprrdippprrdippprrdc<CR>
<LF>

ttt – GPS time ref	0 .. 6047999
	(0.0 .. 604799.9)
i – Sat ID	0..37
	0 = not used
	1-37 = sat ID
ppp – pseudorange corr	-1,048,576 ..
	+1,048,576
0.01 meter resolution	(-10485.76 ..
	+10485.76)
rr – pseudorange-rate corr	-4096 .. 4096
0.001 m/s resolution	(-4.096 .. 4.096)
d – issue of data ephemeris	0 .. 255

C – checksum
Message Length: 52 bytes

RESPONSE MESSAGE:

- *(to command):*

@@Ckc<CR><LF>

C – checksum
Message Length: 7 bytes

INPUT PSEUDORANGE CORRECTION

MOTOROLA BINARY FORMAT

SET-TO-DEFAULTS

This utility sets all the GPS Receiver parameters to their factory default values. Performance of this utility results in all continuous messages being reset to polled output, clears pseudorange corrections contained in the GPS Receiver, and clears almanac/ephemeris data. However, the time and date stored in the internal real-time clock is not changed by performance of this utility.

INPUT COMMAND DESCRIPTION:

- Set PVT6 GPS Receiver to default values:

  @@Cfc<CR><LF>

  C – checksum
  Message Length: 7 bytes

RESPONSE MESSAGE:

- *(to command):*

  @@Cfc<CR><LF>

  C – checksum
  Message Length: 7 bytes

SET-TO-DEFAULTS

MOTOROLA BINARY FORMAT

POSITION FIX/IDLE MODE OPTION

This utility allows the user to place the GPS Receiver into one of two operating modes: Position Fix mode or Idle mode. The Position Fix mode is the normal operating mode of the GPS Receiver in which it acquires and tracks satellites and computes position from the satellite measurements. The Idle mode is a reduced power mode in which the GPS Receiver does not track satellites. The receiver's MPU is active only while it operates on input commands and creates output response messages. All other times, the receiver is placed in a low-power wait-state in which it waits for the next command string to be entered via the RS232 port.

INPUT COMMAND DESCRIPTION:

- Select Operating Mode:

@@CgmC<CR><LF>

m – mode 0 .. 2
0 – go to Idle mode
1 – Go to Position Fix Mode
2 – Send current receiver Mode

C – checksum
Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to command)*

@@CgmC<CR><LF>

m – mode 0 .. 1
0 – Idle Mode
1 – Position Fix Mode

C – checksum
Message Length: 8 bytes

Note: The response message is output when the GPS Receiver reaches the desired mode. For example, if the GPS Receiver is in the Position Fix mode and the user issues the Idle mode command, the response message occurs only after the GPS Receiver is configured into the low-power Idle mode. This can take several seconds, depending on the current status of the GPS Receiver. For example, if the receiver is storing almanac data to its internal nonvolatile memory (EEPROM), the Idle mode will be reached only after the completion of the storage of the data. This can take at least 12 seconds to accomplish.

POSITION FIX/IDLE MODE OPTION

MOTOROLA BINARY FORMAT

SWITCH I/O FORMAT

This utility command switches GPS Receiver from Motorola Binary Format to one of the other embedded formats.

INPUT COMMAND DESCRIPTION:

- Select I/O format:

  @@CimC<CR><LF>

  m – format
  - 0 – Motorola Binary Format
  - 1 – NMEA-0183 Format
  - 2 – LORAN Emulation Format

  C – checksum

  Message Length: 8 bytes

RESPONSE MESSAGE:

- *(to command):*

  NOTE: There is no response message to this input command. The GPS Receiver configures the RS232 port parameters (baud rate, start bits, stop bits, etc.) to the selected format, and input commands are recognized in this new format only.

SWITCH I/O FORMAT

MOTOROLA BINARY FORMAT

RECEIVER ID COMMAND STRING

The GPS Receiver outputs an ID message upon request. The information contained in the ID string is self-explanatory.

INPUT COMMAND DESCRIPTION:

- Request ID string:

  @@CjC<CR><LF>

  C – checksum
  Message Length: 7 bytes

RESPONSE MESSAGE:

- *(to command):*

  @@Cj<CR><LF>

  COPYRIGHT 1991-199x MOTOROLA INC.<CR><LF>

  SFTW P/N # XXXXXXXXXXXXXXX<CR><LF>

  SOFTWARE VER # XXXXXXXXXXX<CR><LF>

  SOFTWARE DATE # XXXXXXXXXXX<CR><LF>

  MODEL # XXXXXXXXXXXXXXX<CR><LF>

  HDWR P/N # XXXXXXXXXXXXXXX<CR><LF>

  SERIAL # XXXXXXXXXXXXXXX<CR><LF>

  MANUFACTURE DATE XXXXXXXXXX <CR><LF>

  OPTIONS LIST XXXXXXXXXXC<CR><LF>

  C – checksum
  Message Length: 294 bytes

RECEIVER ID COMMAND STRING

MOTOROLA BINARY FORMAT

4.7.2 NMEA-0183 Format.

GPGGA (LATITUDE/LONGITUDE)

This command enables the GPGGA Latitude/ Longitude message and determines the rate at which the information is transmitted.

INPUT COMMAND DESCRIPTION:

$PMOTG,GGA,yyyy*CC<CR><LF>

yyyy – update rate	0 .. 9999 sec
CC – Optional Checksum	hex 00 .. 7f

MESSAGE RESPONSE:

$GPGGA,hhmmss.ss,ddmm.mmm,n,dddmm.mmm,e,q,ss,y.y,a.a,z,g.g,z,t.t,iiii*CC<CR><LF>

hhmmss.ss – UTC of position	
hh – hours	00 .. 24
mm – minutes	00 .. 59
ss.ss – seconds	00.000 .. 59.999
ddmm.mmm,n – latitude	
dd – degrees	00 .. 90
mm.mmm – minutes	00.000 .. 59.999
n – direction	N – north
	S – south
dddmm.mmm,e – longitude	
ddd – degrees	000 ..180
mm.mmm – minutes	00.00 .. 59.99
e – direction	E – east
	W – west
q – GPS quality indicator	0 – GPS not available
	1 – GPS available
	2 – GPS differential fix
ss – Number of sat being used	0 .. 12
y.y – HDOP	
a.a,z – antenna height	
a.a – height	
z – units	M – meters
g.g,z – geoidal height	
g.g – height	
z – units	M – meters
t.t – age of differential data	
iiii – differential reference station ID	0000 . . 1023
CC – Checksum	hex 00 .. 7f

GPGGA (LATITUDE/LONGITUDE)

MOTOROLA BINARY FORMAT

GPRMC (GPS TRANSIT SPECIFIC)

This command enables the GPRMC GPS Transit Specific message and determines the rate at which the information is transmitted.

INPUT COMMAND DESCRIPTION:

$PMOTG,RMC,yyyy*CC<CR><LF>

yyyy – update rate	0 .. 9999 sec
CC – Optional Checksum	hex 00 .. 7F

MESSAGE RESPONSE:

$GPRMC,hhmmss.ss,a,ddmm.mmm,n,dddmm.mmm,w,z.z,y.y,ddmmyy,d.d,v*CC<CR><LF>

hhmmss.ss – UTC time	
hh – hours	00 .. 24
mm – minutes	00 .. 59
ss.ss – seconds	00.00 .. 59.99
a – status	A – valid
	V – invalid
ddmm.mmm,n – latitude	
dd – degrees	00 .. 90
mm.mmm – minutes	00.000 .. 59.999
n – direction	N – north
	S – south
dddmm.mmm,w - longitude	
ddd – degrees	00 .. 90
mm.mmm – minutes	00.000 .. 59.999
w – direction	E – east
	W – west
z.z – speed over ground (knots)	0.0 . . 99.9
y.y – course over ground (reference to true north)	0.0 .. 359.9
ddmmyy – day/month/year	
dd – day	01 .. 31
mm – month	01 .. 12
yy – year	00 .. 99
d.d – magnetic variation (degrees)	0 .. 99.9
v – variation sense	E – east
	W – west
CC – Checksum	hex 00 .. 7f

GPRMC (GPS TRANSIT SPECIFIC)

MOTOROLA BINARY FORMAT

GPGLL (LATITUDE/LONGITUDE)

This command enables the GPGLL Latitude/ Longitude message and determines the rate at which the information is transmitted.

INPUT COMMAND DESCRIPTION:

$PMOTG,GLL,yyyy*CC<CR><LF>

yyyy – update rate	0 .. 9999 sec
CC – Optional Checksum	hex 00 .. 7f

MESSAGE RESPONSE:

$GPGLL,ddmm.mmm,n,dddmm.mmm,e,hhmmss.ss,a*CC<CR><LF>

ddmm.mmm,n – latitude	
dd – degrees	00 .. 90
mm.mmm – minutes	00.000 .. 59.999
n – direction	N – north
	S – south
dddmm.mmm,e – longitude	
ddd – degrees	00 ..180
mm.mmm – minutes	00.000 .. 59.999
e – direction	E – east
	W – west
hhmmss.ss – UTC of position	
hh – hours	00 ..24
mm – minutes	00 .. 59
ss.ss – seconds	00.00 .. 59.99
a – status	A – valid
	V – invalid
CC – Checksum	hex 00 .. 7f

GPGLL (LATITUDE/LONGITUDE)

MOTOROLA BINARY FORMAT

GPGSA (GPS DOP AND ACTIVE SATELLITES)

This command enables the GPGSA GPS DOP and Active Satellites message and determines the rate at which the information is transmitted.

INPUT COMMAND DESCRIPTION:

$PMOTG,GSA,yyyy*CC<CR><LF>

yyyy – update rate	0 .. 9999 sec
CC – Optional Checksum	hex 00 .. 7f

MESSAGE RESPONSE:

$GPGSA,a,b,cc,dd,ee,ff,gg,
hh,ii,jj,kk,mm,nn,oo,p.p,
q.q,r.r*CC<CR><LF>

a – sat acquisition mode	M – manual (forced to operate in 2-D or 3-D mode) A – automatic (auto switch 2-D/3-D)
b - pos mode	1 – fix not available 2 – 2-D 3 – 3-D
cc, dd, ee, ff, gg, hh, ii, jj kk, mm, nn, oo	Sat IDs used in solution (null for unused fields)
p.p – PDOP	1.0 .. 9.9
q.q – HDOP	1.0 .. 9.9
r.r – VDOP	1.0 .. 9.9
CC – Checksum	hex 00 .. 7f

GPGSA (GPS DOP AND ACTIVE SATELLITES)

MOTOROLA BINARY FORMAT

MAGNETIC VARIANCE INPUT

This input command sets the magnetic variance as applied to heading information in the GPRMC (GPS Transit Specific) response message. Once input, the magnetic variance value assigned is stored in nonvolatile memory.

INPUT COMMAND DESCRIPTION:

$PMOTG,MAG,xx,v*CC<CR><LF>

xx – magnetic variation (degrees) 00 .. 99
v – variation sense E = east
W = west
CC – Optional Checksum hex 00 .. 7f

RESPONSE MESSAGE:

There is no response to this input command.

MAGNETIC VARIANCE INPUT

MOTOROLA BINARY FORMAT

SWITCH I/O FORMAT

This utility command switches the the PVT6 GPS Receiver I/O protocol from NMEA-0183 Format to one of the embedded formats. The format selected is retained in nonvolatile memory.

INPUT COMMAND DESCRIPTION:

- Select Format:

$PMOTG,FOR,x*CC<CR><LF>

x – format	0 – Motorola Binary Format 1 – NMEA-0183 Format 2 – LORAN Format
CC – Checksum	hex 00 .. 7f

RESPONSE MESSAGE:

- *(to command):*

NOTE: There is no response message to this input command. The GPS Receiver configures the RS232 port parameters (baud rate, start bits, stop bits, etc.) to the selected format, and input commands are recognized in this new format only.

POSITIONING DATA OUTPUT RATE

The user can select a timed output rate (up to 2.77 hours in 1 second increments), or request the position output to occur immediately. The output rate selected is stored in the GPS Receiver nonvolatile memory.

Using the polled input command results in the response message (containing position fix information) to be output immediately. The response message is in printable ASCII characters.

INPUT COMMAND DESCRIPTION:

Z<CR><LF>

RESPONSE MESSAGE:

ddmmhhNdddmmhhWSSSDDDQ<CR><LF>

ddmmhhN – latitude	
dd – degrees	00 .. 90
mm – minutes	00 .. 59
hh – resolution .01	0.00 .. 0.99
N – direction	N – north
	S – south
dddmm.xx,e – longitude	
dd – degrees	00 .. 90
mm – minutes	00 .. 59
hh – resolution .01	0.00 .. 0.99
W – direction	E – east
	W – west
SSS – speed m/p/h	
DDD – Direction (referenced to true?hold)	
Q – Quality factor	1 – 2D or 3D avail
	0 – positioning data not avail

POSITIONING DATA OUTPUT RATE

MOTOROLA BINARY FORMAT

OUTPUT TIME INTERVAL

This commands sets the rate of transmission of the positioning information response messages.

INPUT COMMAND DESCRIPTION:

Tssss<CR><LF>
or
T<CR><LF>

ssss – Time interval in sec 0 .. 9999

RESPONSE MESSAGE:

Tssss<CR><LF>

ssss – Time interval in sec 0 .. 9999

and

ddmmhhNdddmmhhWSSSDDDQ<CR>
<LF>

ddmmhhN – latitude
- dd – degrees 00 .. 90
- mm – minutes 00 .. 59
- hh – resolution .01 0.00 .. 0.99
- N – direction N – north, S – south

dddmm.xx,e – longitude
- dd – degrees 00 .. 90
- mm – minutes 00 .. 59
- hh – resolution .01 0.00 .. 0.99
- W – direction E – east, W – west

SSS – speed m/p/h
DDD – Direction (referenced to true-hold)
Q – Quality factor 1 – 2D or 3D avail, 0 – positioning data not avail

SWITCH I/O FORMAT

This utility command switches the GPS Receiver from LORAN Emulation Format to one of the other embedded formats.

INPUT COMMAND DESCRIPTION:

- Select Motorola Binary Format:

  BIN<CR><LF>

- Select NMEA?0183 Format:

  NMEA<CR><LF>

RESPONSE MESSAGE:

- *(to command):*

  NOTE: There is no response message to this input command. The PVT6 GPS Receiver reconfigures the RS232 port parameters (baud rate, start bits, stop bits, etc) to the selected format, and input commands are recognized in this new format only.

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APPENDIX A GLOSSARY OF GPS TERMS

Almanac	Data transmitted by a GPS satellite which includes orbit information on all the satellites, clock correction, and atmospheric delay parameters. These data are used to facilitate rapid satellite acquisition. The orbit information is a subset of the ephemeris data with reduced accuracy.
Ambiguity	The unknown integer number of cycles of the reconstructed carrier phase contained in an unbroken set of measurements from a single satellite pass at a single receiver.
Argument of Latitude	The sum of the true anomaly and the argument of perigee.
Argument of Perigee	The angle or arc from the ascending node to the closest approach of the orbiting body to the focus or perigee point, as measured at the focus of an elliptical orbit, in the orbital plane in the direction of motion of the orbiting body.
Ascending Node	The point at which an object's orbit crosses the reference plane (e.g. equatorial plane) from south to north.
Azimuth	A horizontal direction expressed as the angular distance between a fixed direction, such as North, and the direction of the object.
Bandwidth	A measure of the information-carrying capacity of a signal, expressed as the width of the spectrum of that signal (frequency domain representation) in Hertz.
Baseline	The three-dimensional (3D) vector distance between a pair of stations for which simultaneous GPS data has been collected and processed with differential techniques. The most accurate GPS result.
Beat Frequency	Either of two additional frequencies obtained when signals of two frequencies are mixed. The beat frequencies are equal to the sum or difference of the original frequencies.
Bias	See Integer Bias Terms.
Binary Biphase Modulation	Phase changes of either 0 or 180 degrees on a constant frequency carrier representing a binary 0 or 1 respectively). GPS signals are biphase modulated.

Binary Pulse Code Modulation	Pulse modulation using a string of binary numbers (codes). This coding is usually represented by ones and zeros with definite meanings assigned to them, such as changes in phase or direction of a wave.
Bluebook	A slang term derived from a blue NGS reference book. The book contains information and formats required by NGS for survey data that is submitted to be considered for use in the national network.
C/A Code	The Coarse/Acquisition (or Clear/Acquisition) code modulated onto the GPS L1 signal. This code is a sequence of 1023 pseudorandom binary biphase modulations on the GPS carrier at a chipping rate of 1.023 MHz, thus having a code repetition period of one millisecond. This code was selected to provide good acquisition properties.
Carrier	A radio wave having at least one characteristic (such as frequency, amplitude, phase) which may be varied from a known reference value by modulation.
Carrier Beat Phase	The phase of the signal which remains when the incoming Doppler-shifted satellite carrier signal is beat (the difference frequency signal is generated) with the nominally constant reference frequency generated in the receiver.
Carrier Frequency	The frequency of the unmodulated fundamental output of a radio transmitter. The GPS L1 carrier frequency is 1575.42 MHz.
Celestial Equator	The great circle that is the projection of the earth's geographical equator of rotation onto the celestial sphere. Its poles are the North and South Celestial Poles.
Celestial Meridian	That vertical circle through the elevated celestial pole. It also passes through the other celestial pole, the astronomical zenith, and the nadir.
Chip	The length of time to transmit either a 0 or 1 in binary pulse code.
Chip Rate	Number of chips per second (e.g. C/A code = 1.023 MHz).
Clock Offset	Constant difference in the time reading between two clocks.
Code Division Multiple Access (CDMA)	A method of frequency reuse whereby many radios use the same frequency but with each one having a separate and unique code. GPS uses CDMA techniques with Gold's codes for their unique cross-correlation properties.

Conventional International Origin (CIO)	Average position of earth's rotation axis during the years 1900-1905.
Correlation-Type Channel	A GPS receiver channel which uses a delay-lock-loop to maintain an alignment (correlation peak) between the replica of the GPS code generated in the receiver and the received code.
Deflection of the Vertical	The angle between the normal to the ellipsoid and the vertical (true plumbline). Since this angle has both a magnitude and a direction, it is usually resolved into two components: one in the meridian and the other perpendicular to it in the prime vertical.
Delay Lock	The technique whereby the received code (generated by the satellite clock) is compared with the internal code (generated by the receiver clock) and the latter is shifted in time until the two codes match. Delay-lock-loops can be implemented in several ways: tau dither and early-minus-late gating.
Delta Pseudorange	See Reconstructed Carrier Phase.
Differential Processing	GPS measurements can be differenced between receiver, satellites, and epochs. Although many combinations are possible, the present convention for differential processing of GPS phase measurements, is to take differences between receivers (single difference), then between satellite (double difference), then between measurement epochs (triple difference). A single-difference measurement between receivers is the instantaneous difference in phase of the signal from the same satellite, measured by two receivers simultaneously. A double-difference measurement is obtained by differencing the single difference for one satellite with respect to the corresponding single difference for a chosen reference satellite. A triple-difference measurement is the difference between a double difference at one epoch of time and the same double difference at the previous epoch of time.

Differential (relative) Positioning	Determination of relative coordinates of two or more receivers which are simultaneously tracking the same satellites. Dynamic differential positioning is a real-time calibration technique achieved by sending corrections to the roving user from one or more monitor stations. Static differential GPS involves determining baseline vectors between pairs of receivers.
Dilution of Precision	A description of the purely geometrical contribution to the uncertainty in a position fix, given by the expression DOP = SQRT TRACE (A A) where A A is the design matrix for the instantaneous position solution (dependent on satellite-receiver geometry). The DOP factor depends on the parameters of the position-fix solution. Standard terms for the GPS application are: GDOP: Geometric (three position coordinates plus clock offset in the solution) PDOP: Position (three coordinates) GDOP: Horizontal (two horizontal coordinates) VDOP: Vertical (height only) TDOP: Time (clock offset only) RDOP: Relative (normalized to 60 seconds)
Doppler Aiding	The use of Doppler carrier-phase measurements to smooth code-phase position measurements.
Doppler Shift	The apparent change in frequency of a received signal due to the rate of change of the range between the transmitter and receiver. See Reconstructed Carrier Phase.
Double-Difference Method	A method to determine that set of ambiguity values which minimizes the variance of the solution for a receiver pair baseline vector.
Dynamic Positioning	Determination of a timed series of sets of coordinates for a moving receiver, each set of coordinates being determined from a single data sample, and usually computed in real time.
Earth-Centered Earth-Fixed (ECEF)	Cartesian coordinate system where the X direction is the intersection of the prime meridian (Greenwich) with the equator. The vectors rotate with the earth. Z is the direction of the spin axis.
Eccentric Anomaly E	The regularizing variable in the two-body problem. E is related to the mean anomaly M by Kepler's equation: M = E - e.sinE (e = eccentricity).

Eccentricity	The ratio of the distance from the center of an ellipse to its focus to the semimajor axis. $e = (1 - b2/a2)^{-1/2}$ where a and b are the semimajor and semiminor axis of the ellipse.
Ecliptic	The earth-sun orbital plane. North is the direction of the system's angular momentum. Also called the ecliptic pole.
Elevation	Height above mean sea level. Vertical distance above the geoid.
Elevation Mask Angle	That angle below which we recommend that you do not track satellites. Normally set to 15 degrees to avoid interference problems caused by buildings and trees, and multipath errors.
Ellipsoid Height	The measure of vertical distance above the ellipsoid. Not the same as elevation above sea level. GPS receivers output position fix height in the WGS-84 datum.
Ephemeris	A list of (accurate) positions or locations of a celestial object as a function of time. Available as "broadcast ephemeris" or as postprocessed "precise ephemeris".
Epoch	Measurement interval or data frequency, as in making observations every 15 seconds. Loading data using 30-second epochs, means loading every other measurement.
Fast Switching	A switching channel with a sequence time short enough to recover (through software Channel prediction) the integer part of the carrier beat phase.
Flattening	$f = (a - b)/a = 1 - (1 - e^2)^{1/2}$ a = semimajor axis b = semiminor axis e = eccentricity
Frequency Band	A range of frequencies in a particular region of the electromagnetic spectrum.
Frequency Spectrum	The distribution of amplitudes as a function of frequency of the constituent waves in a signal.
Fundamental Frequency	The fundamental frequency used in GPS is 10.23 MHz. The carrier frequencies L1 and L2 are integer multiples of this fundamental frequency. L1 = 154F = 1575.42 MHz L2 = 120F = 1227.60 MHz

GDOP — Geometric Dilution of Precision. The relationship between errors in user position and time and in satellite range. See Dilution of Precision.

$GDOP^2 = PDOP^2 + TDOP^2$

Geocenter — The center of the earth.

Geodetic Datum — A mathematical model designed to best fit part or all of the geoid. It is defined by an ellipsoid and the relationship between the ellipsoid and a point on the topographic surface established as the origin of datum. This relationship can be defined by six quantities, generally (but not necessarily) the geodetic latitude, longitude, and the height of the origin, the two components of the deflection of the vertical at the origin, and the geodetic azimuth of a line from the origin to some other point.

Geoid — The particular equipotential surface which coincides with mean sea level, and which may be imagined to extend through the continents. This surface is everywhere perpendicular to the force of gravity.

Geoid Height — The height above the geoid is often called elevation above mean sea level.

GPS — Global Positioning System, consisting of:

- the space segment (up to 24 NAVSTAR satellites in six different orbits)
- the control segment (five monitor stations, one master control station and three upload stations
- the user segment (GPS receivers)

NAVSTAR satellites carry extremely accurate atomic clocks and broadcast coherent simultaneous signals.

GPS ICD-200 — The GPS Interface Control Document is a government document that contains the full technical description of the interface between the satellites and the user. GPS receivers must comply with this specification if they are to receive and process GPS signals properly.

Gravitational Constant — The proportionality constant in Newton's Law of Gravitation:

$G = 6.672 \times 10^{-11} Nm^2/Kg^2$

Greenwich Mean Time (GMT) — See Universal Time.

HDOP	Horizontal Dilution of Precision. See Dilution of Precision.
HOW	Handover Word. The word in the GPS message that contains time synchronization information for the transfer from the C/A code to the P code.
Inclination	The angle between the orbital plane of a body and some reference plane (e.g. equatorial plane)
INS	Inertial Navigation System, which contains an Inertial Measurement Unit (IMU).
Integer Bias Terms	The receiver counts the radio waves from the satellite, as they pass the antenna, to a high degree of accuracy. However, it has no information on the number of waves to the satellite at the time it started counting. This unknown number of wavelengths between the satellite and the antenna is the integer bias term.
Integrated Doppler	A measurement of Doppler shift frequency or phase over time.
Ionospheric Delay	A wave propagating through the ionosphere (which is nonhomogeneous in space and time, and dispersive medium) experiences delay. Phase delay depends on electron content and affects carrier signals. Group delay depends on dispersion in the ionosphere as well, and affects signal modulation (codes). The phase and group delay are of the same magnitude but opposite sign.
Ipar Soln	Values giving the difference in each of delta X, delta Y, and delta Z vector components.
JPO	Joint Program Office for GPS located at the USAF Space Division at El Segundo, California. The JPO consists of the USAF Program Manager and Deputy Program Managers representing the Army, Navy, Marine Corps, Coast Guard, Defense Mapping Agency, and NATO.
Kalman Filter	A numerical method used to track a time-varying signal in the presence of noise. If the signal can be characterized by some number of parameters that vary slowly with time, then Kalman filtering can be used to tell how incoming raw measurements should be processed to best estimate those parameters as a function of time.
Kinematic Surveying	A form of continuous differential carrier-phase surveying requiring only short periods of data observations. Operational constraints include starting from or determining a known baseline, and tracking a minimum of four satellites. One receiver is statically located at a control point, while others are moved between points to be measured.

Keplerian Orbital Elements	Allow description of any astronomical orbit: a = semimajor axis b = eccentricity o = argument of perigee l = right ascension of ascending node i = inclination t = true anomaly
L1	The primary L-band signal radiated by each NAVSTAR satellite at 1575.42 MHz. The L1 beacon is modulated with the C/A and P codes, and with the NAV message. L2 is centered at 1227.60 MHz and is modulated with the P code and the NAV message.
Lane	The area (or volume) enclosed by adjacent lines (or surfaces) of zero phase of either the carrier beat phase signal, or of the difference between two carrier beat phase signals. On the earth's surface a line of zero phase is the locus of all points for which the observed value would have an exact integer value for the complete instantaneous phase measurement. In three dimensions, this locus becomes a surface.
L Band	The radio frequency band extending from 390 MHz to (nominally) 1550 MHz.
Mean Anomaly	M = n (t - T) where n is the mean motion, t is the time, and T is the instant of perigee passage.
Mean Motion	n = 2/P where P is the period of revolution.
Microstrip Antenna	A two-dimensional, flat, precisely cut piece of metal foil glued to a substrate.
Monitor Station	Worldwide group of stations used in the GPS control segment to monitor satellite clock and orbital parameters. Data collected here is linked to a Master Station where corrections are calculated and controlled. These data are uploaded to each satellite at least once per day from an Upload Station.
Multichannel Receiver	A receiver containing many independent channels. Such a receiver offers highest signal-to-noise ratio (SNR) because each channel tracks one satellite continuously.

Multipath	Interference similar to "ghosts" on a television screen which occurs when GPS signals arrive at an antenna having traversed different paths. The signal traversing the longer path will yield a larger pseudorange estimate and increase the error. Multiple paths may arise from reflections from structures near the antenna.
Multipath Error	A positioning error resulting from interference between radio waves which have traveled between the transmitter and the receiver by two paths of different electrical lengths.
Multiplexing Channel	A receiver channel which is sequenced through several satellite signals (each from a specific satellite and at a specific frequency) at a rate which is synchronous with the satellite message bit-rate (50 bits per second, or 20 milliseconds per bit). Thus, one complete sequence is completed in a multiple of 20 milliseconds.
NAD-83	North American Datum, 1983
NAVDATA	The 1500-bit Navigation Message broadcast by each satellite at 50 bps on both L1 or L2 beacons. This message contains system time, clock correction parameters, ionospheric delay model parameters, and the vehicle's ephemeris and health. This information is used to process GPS signals to obtain user position and velocity.
NAVSTAR	The name given to GPS satellites, built by Rockwell International, which is an acronym formed from NAViation System with Time and Ranging.
Observing Session	The period of time over which GPS data is collected simultaneously by two or more receivers.
Outage	The occurrence in time and space of a GPS dilution of precision value exceeding a specified maximum.
P Code	The protected or precise code used on both L1 and L2 GPS beacons. This code will be made available by the DoD only to authorized users. The P code is a vary long (about 10^{14} bits) sequence of pseudorandom binary biphase modulations on the GPS carrier at a chipping rate of 10.23 MHz which does not repeat itself for about 38 weeks. Each satellite uses a one-week segment of this code which is unique to each GPS satellite, and is reset each week.

PDOP	Position Dilution of Precision, a unitless figure of merit expressing the relationship between the error in user position and the error in satellite position. Geometrically, PDOP is proportional to 1 divided by the volume of the pyramid formed by lines running from the receiver to four satellites observed. Values considered good for positioning are small, such as 3. Values greater than 7 are considered poor. Thus, small PDOP is associated with widely separated satellites. A small value of PDOP is important in positioning, but much less so in surveying.
Parity Error	A digital message is composed of 1s and 0s. Parity can be defined as the sum of these bits within a word unit. A parity error results when one of the bits is changed so that the parity calculated at reception is not the same as it was at transmission of the message.
Perigee	That point in a geocentric orbit when the geometric distance is a minimum. The closest approach of a body.
Phase Lock	The technique whereby the phase of an oscillator signal is made to follow exactly the phase of a reference signal by first comparing the phases of the two signals, and then using the resulting phase difference signal to adjust the reference oscillator frequency to eliminate phase difference when the two signals are next compared.
Phase Observable	See Reconstructed Carrier Phase.
Point Positioning	A geographic position produced from one receiver in a stand-alone mode. At best, position accuracy obtained from a stand-alone receiver is 15 - 25 meters, depending on the geometry of the satellites.
Polar Motion	Motion of the instantaneous axis of the rotation of the earth with respect to the solid body of the earth. Irregular but more or less circular motion with an amplitude of about 15m and a main period of about 430 days (called Chandler Wobble).
Precise Positioning Service (PPS)	The highest level of military dynamic positioning accuracy that will be provided by GPS, based on the dual frequency P code and having high anti-jam and anti-spoof qualities.
Prime Vertical	The vertical circle perpendicular to the celestial meridian.

PRN	Pseudorandom noise, a sequence of digital 1s and 0s which appear to be randomly distributed like noise, but which can be exactly reproduced. The important property of PRN codes is that they have a low autocorrelation value for all delays or lags except when they are exactly coincident. Each NAVSTAR satellite has its own unique C/A and P pseudorandom-noise codes.
Pseudolite	A ground-based GPS transmitter station which broadcasts a signal with a structure similar to that of an actual GPS satellite.
Pseudorange	A measure of the apparent propagation time from the satellite to the receiver antenna, expressed as a distance. Pseudorange is obtained by multiplying the apparent signal-propagation time by the speed of light. Pseudorange differs from the actual range by the amount that the satellite and user clocks are offset, by propagation delays, and other errors. The apparent propagation time is determined from the time shift required to align (correlate) a replica of the GPS code generated in the receiver with the received GPS code. The time shift is the difference between the time of signal reception (measured in the receiver time frame) and the time of emission (measured in the satellite time frame).
Pseudorange Difference	See Reconstructed Carrier Phase.
Range Rate	The rate of change of range between the satellite and receiver. The range to a satellite changes due to satellite and observer motions. Range rate is determined by measuring the doppler shift of the satellite beacon carrier.
RDOP	Relative Dilution of Precision. See Dilution of Precision.
Reconstructed Carrier Phase	The difference between the phase of the incoming Doppler-shifted GPS carrier and the phase of a nominally constant reference frequency generated in the receiver. For static positioning, the reconstructed carrier phase is sampled at epochs determined by a clock in the receiver. The reconstructed carrier phase changes according to the continuously integrated Doppler shift of the incoming signal, biased by the integral of the frequency offset between the satellite and receiver reference oscillators. The reconstructed carrier phase can be related to the satellite-to-receiver range, once the initial range (or phase ambiguity) has been determined. A change in the satellite-to-receiver range of one wavelength of the GPS carrier (19 cm for L1) will result in a one-cycle change in the phase of the reconstructed carrier.

Relative Navigation	A technique similar to relative positioning except that one or both of the points may be moving. The pilot of a ship or aircraft may need to know his position relative to a harbor or runway. A data link is used to relay the error terms to the moving vessel to allow real-time navigation.
Right Ascension of Ascending Node	The angular distance measured from the vernal equinox, positive to the east, along the celestial equator to the ascending node. Typically denoted by a capital omega. Used to discriminate between orbital planes.
RTCM	Radio Technical Commission for Maritime Services. commission set up to define a differential data link to relay GPS correction messages from a monitor station to a field user. RTCM SC-104 recommendations define the correction message format and 16 different correction message types.
SATNAV	A local term referring to use of the older TRANSIT system for satellite navigation. One major difference between TRANSIT and GPS is that the TRANSIT satellites are in low-altitude polar orbits with a 90-minute period.
Selective Availability (SA)	A DoD program to control the accuracy of pseudorange measurements, whereby the user receives a false pseudorange which is in error by a controlled amount. Differential GPS techniques can reduce these effects for local applications.
Semimajor Axis	One-half of the major axis of an ellipse.
SEP	Spherical Error Probable, a statistical measure of precision defined as the 50th percentile value of the three-dimensional position error statistics. Thus, half of the results are within a 3D DEP value.
Sidereal Day	Time between two successive upper transits of the vernal equinox.
Simultaneous Measurements	Measurements referenced to time-frame epochs which are either exactly equal, or so closely spaced in time that the time misalignment can be accommodated by correction terms in the observation equation, rather than by parameter estimation.
Slope Distance	The three-dimensional vector distance from station one to station two. The shortest distance (a chord) between two points.
Slow Switching Channel	A switching channel with a sequencing period which is too long to allow recovery recovery of the integer part of the carrier beat phase.
Solar Day	Time between two successive upper transits of the sun.

Spheroid	See Ellipsoid.
Spread Spectrum	The received GPS signal is a wide bandwidth, low-power signal (-160 dBW). This property results from modulating the L-band signal with a PRN code in order to spread the signal energy over a bandwidth which is much greater than the signal information bandwidth. This is done to provide the ability to receive all satellites unambiguously and to provide some resistance to noise and multipath.
Spread Spectrum System	A system in which the transmitted signal is spread over a frequency band much wider than the minimum bandwidth needed to transmit the information being sent.
SPS	Standard Positioning Service, using the C/A code to provide a minimum level of dynamic or static positioning capability. The accuracy of this service will be set at a level consistent with national security.
Squaring-Type Channel	A GPS receiver channel which multiplies the received signal by itself to obtain a second harmonic of the carrier which does not contain the code modulation. Used in codeless receiver channels.
Static Positioning	Positioning applications in which the positions of static or near-static points are determined.
SV	Satellite vehicle or space vehicle.
Switching Channel	A receiver channel which is sequenced through a number of satellite signals (each from a specific satellite and at a specific frequency) at a rate which is slower than, and asynchronous with, the message data rate.
TDOP	Time Dilution of Precision. See Dilution of Precision.
TOW	Time of Week, in seconds from midnight Sunday UTC.
Translocation	A version of relative positioning which makes use of a known position, such as a JSGS survey mark, to aid in the accurate positioning of a desired point. This position of the mark, determined using GPS, is compared with the accepted value. The three-dimensional differences are then used in the calculations for the second point.
Trop	Tropospheric Correction. The correction applied to the measurement to account for tropospheric delay. This value is obtained from the modified Hopfield model.

True Anomaly — The angular distance, measured in the orbital plane from the earth's center (occupied focus) from the perigee to the current location of the satellite (orbital body).

Universal Time — Local solar mean time at Greenwich Meridian. Some commonly used versions of Universal Time are:

UT0: Universal Time as deduced directly from observations of starts and the fixed numerical relationship between Universal and Sidereal Time (3 minutes, 56.555 seconds).

UT1: UT0 corrected for polar motion.

UT2: UT0 corrected for seasonal variations in the earth's rotation rate.

UTC: Universal Time Coordinated; uniform atomic time system kept very close to UT2 by offsets. Maintained by the U.S. Naval Observatory.

GPS time is directly relatable to UTC:

UTC - GPS = seconds (5 seconds in 1988)

User Range Accuracy (URA) — The contribution to the range-measurement error from an individual error source (apparent clock and ephemeris prediction accuracies), converted into range units, assuming that the error source is uncorrelated with all other error sources. Values less than 10 are preferred.

UTM — Universal Transverse Mercator Map Projection. A special case of the Transverse Mercator projection. Abbreviated as the UTM Grid, it consists of 60 north-south zones, each six degrees wide in longitude.

VDOP — Vertical Dilution of Precision. See Dilution of Precision.

Vernal Equinox — The intersection of the celestial equator with the ecliptic, with the positive sense being from the earth to the sun, as the sun crosses the equator from south to north.

Vertical — The line perpendicular to the geoid at any point. The direction of the force of gravity at that point. Plumb line.

WGS-72 — World Geodetic System (1972); the mathematical reference ellipsoid previously used by GPS, having a semi-major axis of 6378.135 km and a flattening of 1/298.26.

WGS-84	World Geodetic System (1984); the mathematical ellipsoid used by GPS since January 1987.
Z-Count	The GPS satellite clock time at the leading edge of the next data subframe of the transmitted GPS message (usually expressed as an integer number of six seconds).

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APPENDIX B DATUMS

DATUM ID	LOCAL GEODETIC SYSTEM	ELLIPSOID	DX	DY	DZ
1	ARC_1950	Clarke_1880	-143.0	-90.0	-294.0
2	ARC_1960	Clarke_1880	-160.0	-8.0	-300.0
3	AUSTRALIAN_GEODETIC_1966	Australian_National	-133.0	-48.0	+148.0
4	AUSTRALIAN_GEODETIC_1984	Australian_National	-134.0	-48.0	+149.0
5	BOGOTA_OBSERVATORY	International	+307.0	+304.0	-318.0
6	CAMPO_INCHAUSPE	International	-148.0	+136.0	+90.0
7	CAPE	Clarke_1880	-136.0	-108.0	-292.0
8	CARTHAGE	Clarke_1880	-263.0	+6.0	+431.0
9	CHATHAM_1971	International	+175.0	-38.0	+113.0
10	CHUA_ASTRO	International	-134.0	+229.0	-29.0
11	CORREGO_ALLEGRE	International	-206.0	+172.0	-6.0
12	EUROPEAN_1950_WestEurope	International	-87.0	-96.0	-120.0
13	EUROPEAN_1950_CYPRUS	International	-104.0	-101.0	-140.0
14	EUROPEAN_1950_EGYPT	International	-130.0	-117.0	-151.0
15	EUROPEAN_1950_IRAN	International	-117.0	-132.0	-164.0
16	EUROPEAN_1950_SICILY	International	-97.0	-88.0	-135.0
17	EUROPEAN_1979	International	-86.0	-98.0	-119.0
18	GANDAJIKA_BASE	International	-133.0	-321.0	+50.0
19	GEODETIC_DATUM_1949	International	+84.0	-22.0	+209.0
20	HJORSEY_1955	International	-73.0	+46.0	-86.0
21	INDIAN (Thailand/Vietnam)	Everest	+214.0	+836.0	+303.0
22	INDIAN(Bngldsh/India/Nepal)	Everest	+289.0	+734.0	+257.0
23	IRELAND_1965	Airy_Modified	+506.0	-122.0	+611.0
24	KERTAU_1948	Everest_modified	-11.0	+851.0	+5.0
25	LIBERIA_1964	Clarke_1880	-90.0	+40.0	+88.0
26	LUZON	Clarke_1866	-133.0	-77.0	-51.0
27	MASSAWA	Bessel_1841	+639.0	+405.0	+60.0
28	MERCHICH	Clarke_1880	+31.0	+146.0	+47.0
29	MINNA	Clarke_1880	-92.0	-93.0	+122.0
30	NAHRWAN	Clarke_1880	-247.0	-148.0	+369.0
31	NORTH_AMERICAN_1927_CONUS	Clarke_1866	-8.0	+160.0	+176.0
32	NORTH_AMERICAN_1927_ALASKA	Clarke_1866	-5.0	+135.0	+172.0
33	NORTH_AMERICAN_1927_CANADA	Clarke_1866	-10.0	+158.0	+187.0
34	NORTH_AMERICAN_1927_C_AMER	Clarke_1866	0.0	+125.0	+194.0
35	NORTH_AMERICAN_1983	GRS-80	0.0	0.0	0.0
36	OLD_EGYPTIAN	Helmert_1906	-130.0	+110.0	-13.0
37	OLD_HAWAIIAN	Clarke_1866	+61.0	-285.0	-181.0
38	OMAN	Clarke_1880	-346.0	-1.0	+224.0
39	ORD_SRVY_GRT_BRITAIN_1936	Airy	+375.0	-111.0	+431.0
40	PITCAIRN_ASTRO_1967	International	+185.0	+165.0	+42.0
41	QUATAR_NATIONAL	International	-128.0	-283.0	+22.0
42	QORNOQ	International	+164.0	+138.0	-189.0
43	SCHWARZECK	Bessel_1841_in_Nambia	+616.0	+97.0	-251.0
44	SOUTH_AMERICA_1969	South_America_1969	-57.0	+1.0	-41.0
45	TIMBALAI_1948	Everest	-689.0	+691.0	-46.0
46	TOKYO	Bessel_1841	-128.0	+481.0	+664.0
47	ZANDERIJ	International	-265.0	+120.0	-358.0
48	WGS-1972	WGS-72	0.0	0.0	+4.5
49	WGS-1984	WGS-84	0.0	0.0	0.0
50	User Defined	User Defined			
51	User Defined	User Defined			

Ellipsoid Name	Semi-Major Axis	Inverse Flattening
Airy	6377563.396	299.3249646
Airy_Modified	6377340.189	299.3249646
Australian_National	6378160.0	298.25
Bessel_1841	6377397.155	299.1528128
Bessel_1841_in_Nambia	6377483.865	299.1528128
Clarke_1866	6378206.4	294.9786982
Clarke_1880	6378249.145	293.465
Everest	6377276.345	300.8017
Everest_modified	6377304.063	300.8017
GRS-80	6378137.0	298.257222101
Helmert_1906	6378200.0	298.3
International	6378388.0	297.0
South_America_1969	6378160.0	298.25
WGS-72	6378135.0	298.26
WGS-84	6378137.0	298.257223563

APPENDIX C I/O COMMAND QUICK REFERENCE

Table C-1. Motorola Binary Format

INPUT MESSAGE	DESCRIPTION	RESPONSE MESSAGE	REFERENCE
@@**Aa**xxxC<CR><LF>	Send/Change Current Time of Day	@@**Aa**xxxC<CR><LF>	Page 4-20/4-21
@@**Ab**xxxC<CR><LF>	Send/Change Current GMT Correction	@@**Ab**xxxC<CR><LF>	Page 4-22/4-23
@@**Ac**xxxxC<CR><LF>	Send/Change Current Date	@@**Ac**xxxxC<CR><LF>	Page 4-24/4-25
@@**Ad**xxxxC<CR><LF>	Send/Change Current Latitude	@@**Ad**xxxxC<CR><LF>	Page 4-26/4-27
@@**Ae**xxxxC<CR><LF>	Send/Change Current Longitude	@@**Ae**xxxxC<CR><LF>	Page 4-28/4-29
@@**Af**xxxxxC<CR><LF>	Send/Change Current Height	@@**Af**xxxxxxxxC<CR><LF>	Page 4-30/4-31
@@**Ag**xC<CR><LF>	Send/Change Current Satellite Mask Angle	@@**Ag**xC<CR><LF>	Page 4-32/4-33
@@**Ah**xC<CR><LF>	Send/Change Current Satellite Select Mode	@@**Ah**xC<CR><LF>	Page 4-34/4-35
@@**Ai**xxC<CR><LF>	Send/Change Current Satellite Assignment on Channel	@@**Ai**xxC<CR><LF>	Page 4-36/4-37
@@**Aj**xC<CR><LF>	Send/Change Current xDOP Type	@@**Aj**xC<CR><LF>	Page 4-38/4-39
@@**Ak**xxC<CR><LF>	Send/Change Current xDop Hysteresis	@@**Ak**xxC<CR><LF>	Page 4-40/4-41
@@**Al**xxC<CR><LF>	Send/Change Current 3D to 2D DOP Threshold	@@**Al**xxC<CR><LF>	Page 4-42/4-43
@@**Am**xxxxxC<CR><LF>	Send/Change Current Satellite Ignore List	@@**Am**xxxxxC<CR><LF>	Page 4-44/4-45
@@**An**xC<CR><LF>	Send/Change Current Almanac Update Mode	@@**An**xC<CR><LF>	Page 4-46/4-47
@@**Ao**xC<CR><LF>	Output/Change Current Datum ID Number Command	@@**Ap**xxxxxxxxxxxxxxxxxC <CR><LF>	Page 4-48/4-49
@@**Ap**xxxxxxxxxxxxxxxxxxxC<CR><LF>	Output/Change User Defined Datum Parameters Command	@@**Ap**xxxxxxxxxxxxxxxxxxC <CR><LF>	Page 4-50/4-51
@@**Aq**xC<CR><LF>	Send/Change Current Ionospheric Correction Mode	@@**Aq**xC<CR><LF>	Page 4-52/4-53
@@**Ar**xC<CR><LF>	Send/Change Current Position Fix Algorithm Type	@@**Ar**xC<CR><LF>	Page 4-54/4-55

Table C-1. Motorola Binary Format (Continued)

INPUT MESSAGE	DESCRIPTION	RESPONSE MESSAGE	REFERENCE
@@**As**xxxxxxxxxxxxx C<CR><LF>	Send/Change Current Position-Hold Position	@@**As**xxxxxxxxxxx xxC<CR><LF>	Page 4-56/4-57
@@**At**xC<CR><LF>	Send/Change Current Position Hold Mode	@@**At**xC<CR><LF>	Page 4-58/4-59
@@**Au**xxxxxC<CR> <LF>	Send/Change Current Altitude-Hold Height	@@**Au**xxxxxC<CR><LF>	Page 4-60/4-61
@@**Av**xC<CR><LF>	Send/Change Current Altitude Hold Mode	@@**Av**xC<CR><LF>	Page 4-62/4-63
@@**Aw**xC<CR><LF>	Send/Change Current UTC Correction Mode	@@**Aw**xC<CR><LF>	Page 4-64/4-65
@@**Ax**xxC<CR><LF>	Send/Change Current Measurement Epoch Offset	@@**Ax**xxC<CR><LF>	Page 4-66/4-67
@@**Ay**xxxxC<CR><LF>	Send/Change Current One PPS Offset	@@**Ay**xxxxC<CR><LF>	Page 4-68/4-69
@@**Az**xxxxC<CR><LF>	Send/Change Current One PPS Offset	@@**Az**xxxxC<CR><LF>	Page 4-70/4-71
@@**AA**xC<CR><LF>	Send/Change Current Ephemeris Hold Mode	@@**AA**xC<CR><LF>	Page 4-72/4-73
@@**AB**xC<CR><LF>	Send/Change Application Type	@@**AB**xC<CR><LF>	Page 4-74/4-75
@@**AC**xxC<CR><LF>	Sets the DOP Threshold (2-D to 0-D)	@@**AC**xxC<CR><LF>	Page 4-76/4-77
@@**Ba**xC<CR><LF>	Position/Status/Data Input Output	@@**Ba**xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxC <CR><LF>	Page 4-78/4-79
@@**Bb**xC<CR><LF>	Visible Satellite Status Message	@@**Bb**xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxC <CR><LF>	Page 4-80/4-81
@@**Bc**xC<CR><LF>	xDOP Table Status Message	@@**Bc**xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxC<CR><LF>	Page 4-82/4-83
@@**Bd**xC<CR><LF>	Almanac Status Message	@@**Bd**xxxxxxxxxxxxxxxC <CR><LF>	Page 4-84/4-85
@@**Be**xC<CR><LF>	Almanac Data Output Message	@@**Cb**xxxxxxx...xxxxC<CR> <LF>	Page 4-86/4-87

Table C-1. Motorola Binary Format (Continued)

INPUT MESSAGE	DESCRIPTION	RESPONSE MESSAGE	REFERENCE
@@**Bix**C<CR><LF>	Ephemeris Data Output Message	@@**Bf**xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxC<CR><LF>	Page 4-88/4-89
@@**Bgx**C<CR><LF>	Satellite Range Data Output Message	@@**Bgx**xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxxx xxxxC<CR><LF>	Page 4-90/4-91
@@**Bhx**C<CR><LF>	Output Pseudorange Correction Message	@@**Ce**xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxC<CR><LF>	Page 4-92/4-93
@@**Bj**C<CR><LF>	Leap Second Pending Status Message	@@**Bjm**C<CR><LF>	Page 4-94/4-95
@@**Ca**C<CR><LF>	Self-Test Command/Response	@@**Cax**C<CR><LF>	Page 4-96/4-97
@@**Cb**xxxxx...xxC<CR><LF>	Input Almanac Data Message	@@**Chx**C<CR><LF>	Page 4-98/4-99
@@**Bf**xxxxxxxxxxxxxx xxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxx xxxxxC<CR><LF>	Input Ephemeris Data Message	@@**Ce**xxxxxxxxxxxxxx xxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxx xxxxxC<CR><LF>	Page 4-100/4-101
@@**Cd**xxxxxxxxxxxxxx xxxxxxC<CR><LF>	Alert-Planning Input/Output Message	@@**Cd**xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxx xxxxxxxC<CR><LF>	Page 4-102/4-103
@@**Ce**xxxxxxxxxxxxxx xxxxxxxxxxxxxxxxx xxxxxxxxxxxxC <CR><LF>	Input Pseudorange Correction Message	@@**Ck**C<CR><LF>	Page 4-104/4-105
@@**Cf**C<CR><LF>	Set-to-Defaults Command	@@**Cf**C<CR><LF>	Page 4-106/4-107
@@**Cg**xC<CR><LF>	Position/Idle Mode Enter Command	@@**Cg**xC<CR><LF>	Page 4-108/4-109

Table C-1. Motorola Binary Format (Continued)

INPUT MESSAGE	DESCRIPTION	RESPONSE MESSAGE	REFERENCE
@@CixC<CR><LF>	Switch I/O Format Command	There is no response message to this input command. The receiver re-configures the RS232 communications port parameters (baud rate, start bits, stop bits, etc,) to the desired format, and input commands are recognized in the new format only.	Page 4-110/4-111
@@Cj<CR><LF>	Receiver ID Command String	@@Cj<CR><LF> COPYRIGHT 1991-199x MOTOROLA INC.<CR><LF> SFTW P/N # XXXXXXXXXXX XXX<CR><LF> SOFTWARE VER # XXXXXXX XXXX<CR><LF> SOFTWARE REV # XXXXXXX XXXX<CR><LF> SOFTWARE DATE XXXXXXX XXXX<CR><LF> MODEL # XXXXXXXXXXXX XX<CR><LF> HDWR P/N # XXXXXXXXXX XXXX<CR><LF> SERIAL # XXXXXXXXXXXXX X<CR><LF> MANUFACTUR DATE XXXXXXXXX<CR><LF> OPTIONS LIST XXXXXXXXX C<CR><LF>	Page 4-112/113

Table C-2. NMEA-0183 Format

INPUT MESSAGE	DESCRIPTION	RESPONSE MESSAGE	REFERENCE
$PMOTG,GGA,xxxx*xx <CR><LF>	GPGGA (Latitude/Longitude)	**$GPGGA**,xxxxxx.xx,xxxx.xxx,x, xxxxx.xx,x,x,xx,x.x,x.x,x,x.x, x,x.x,xxxx*CC <CR><LF>	Page 4-114/4-115
$PMOTG,RMC,xxxx*xx, <CR><LF>	GPRMC (GPS Transit Specific)	**$GPRMC**,xxxxxx.xx,x,xxxx.xxx,x, xxxxx.xxx,x,x.x,x.x,xxxxxx,x.x, x*CC<CR><LF>	Page 4-116/4-117
$PMOTG,GLL,xxxx*CC, <CR><LF>	GPGLL (Latitude/Longitude)	**$GPGLL**,xxxx.xxx,x,xxxxxx.xxx, x,xxxxxx.xx,x*CC<CR><LF>	Page 4-118/4-119
$PMOTG,GSA,xxxx*CC, <CR><LF>	GPGSA (Latitude/Longitude)	**$GPGSA**,x,x,xx,xx,xx,xx,xx,xx,xx, xx,xx,xx,xx,xx,x.x,x.x,x.x*CC <CR><LF>	Page 4-120/4-121
$PMOTG,MAG,xx,x*CC, <CR><LF>	Magnetic Variance Input	There is no response message to this input command.	Page 4-122/4-123
$PMOTG,FOR,x*CC <CR><LF>	Switch I/O Format	There is no response message to this input command. The GPS Receiver reconfigures the RS232 port parameters (baud rate, start bits, stop bits, etc) to the selected format, and input commands are recongized in this new format only.	Page 4-124/4-125

Table C-3. LORAN Emulation Format

INPUT MESSAGE	DESCRIPTION	RESPONSE MESSAGE	REFERENCE
Z<CR><LF>	Positioning Data	xxxxxxxxxxxxxxxxxxxx <CR><LF>	Page 4-126/4-127
Txxxx<CR><LF>	Sets Positioning Data Output Time Interval	**T**xxxx<CR><LF>d and xxxxxxxxxxxxxxxxxxxx <CR><LF>	Page 4-128/4-129
BIN<CR><LF>	Switches I/O Format to Motorola Proprietary Binary Format	There is no output response message. The GPS Receiver will begin operating in Motorola Proprietary Binary format mode.	Page 4-130/4-131
NMEA<CR><LF>	Switches I/O Format to NMEA-0183 Format	There is no output response message. The GPS Receiver will begin operating in NMEA-0183 format mode.	Page 4-132/4-133

APPENDIX D
GPS REMOTE ANTENNA INSTALLATION

D-1 ANTENNA MODULE

Your Antenna Module contains a low-profile antenna specifically designed for GPS use. GPS signals are received by the antenna, amplified within the antenna assembly, and then relayed to the GPS Receiver Module for processing. A protective housing shields the antenna from wind, rain, and snow.

D-2 CABLE/CONNECTOR REQUIREMENTS

The Antenna Module relays received GPS signals and receives power (5 Vdc @ 25 mA) from the GPS Receiver Module via a single cable.

An RG58 coaxial cable is recommended for proper connection of the Antenna Module to the GPS Receiver Module. A female RF connector located in the base of the Antenna Module provides the necessary interface to the antenna's electrical circuitry. Note that the power loss along the cable should not exceed 6 dB at a frequency of 1575.42 MHz (GPS - L1). For RG58 cables, maximum cable length is restricted to 6 meters to satisfy this 6 dB requirement.

RF connections between the Antenna Module and the GPS Receiver Module are M/A-COM; Omni-Spectra OSX connectors.

OSX connectors - female	5862-5006-13
(Receiver and Antenna)	02-1115421
OSX connectors - male	5837-5006-13
(cable)	02-1088441
	AP 58-017

D-3 MOUNTING

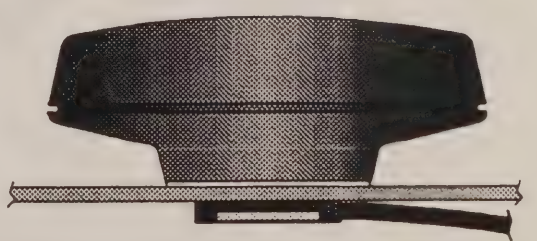
This section discusses (and illustrates) four different antenna mount options available for the Antenna Module:

- Direct Mount Kit
- Lip Mount Kit
- Magnet Mount Kit
- Post Mount Kit

When mounting the Antenna Module, it's important to remember that GPS positioning performance will be most optimal when:

- The antenna patch plane is level with the local geographic horizon
- The antenna has full view of the sky ensuring direct line-of-sight to all visible satellites overhead

D-3.1 Direct Mount Kit Installation. The Direct Mount (Figure D-1) accommodates applications requiring rigid, surface mounting.



DIRECT MOUNT

Figure D-1. Direct Mounted Antenna Module

Refer to Figure D-2 and perform the following steps to install the Direct Mount Kit:

1. Drill a 19 mm hole through the deck plane where you will place the antenna.
2. Insert the Antenna Cable connector to the mating connector on the Antenna Module base.
3. Insert the connector boot over the cable connection and into the circular boot socket.
4. Route the Antenna Cable along the strain relief track located in the base of the Antenna Module. (See cable routing diagram.)
5. Route the Antenna Cable through the hollow slot in the Antenna Module's threaded stem.
6. Remove peel-off liner from the outer gasket and attach the gasket to the bottom of the mounting shroud.
7. Insert the threaded stem through the mounting shroud, outer gasket and deck plane.
8. Install and tighten the cable retaining nut to the threaded stem of the Antenna Module.

NOTE: For low profile cable mounting, route the Antenna Interface Cable through the side slot in the cable retaining nut.

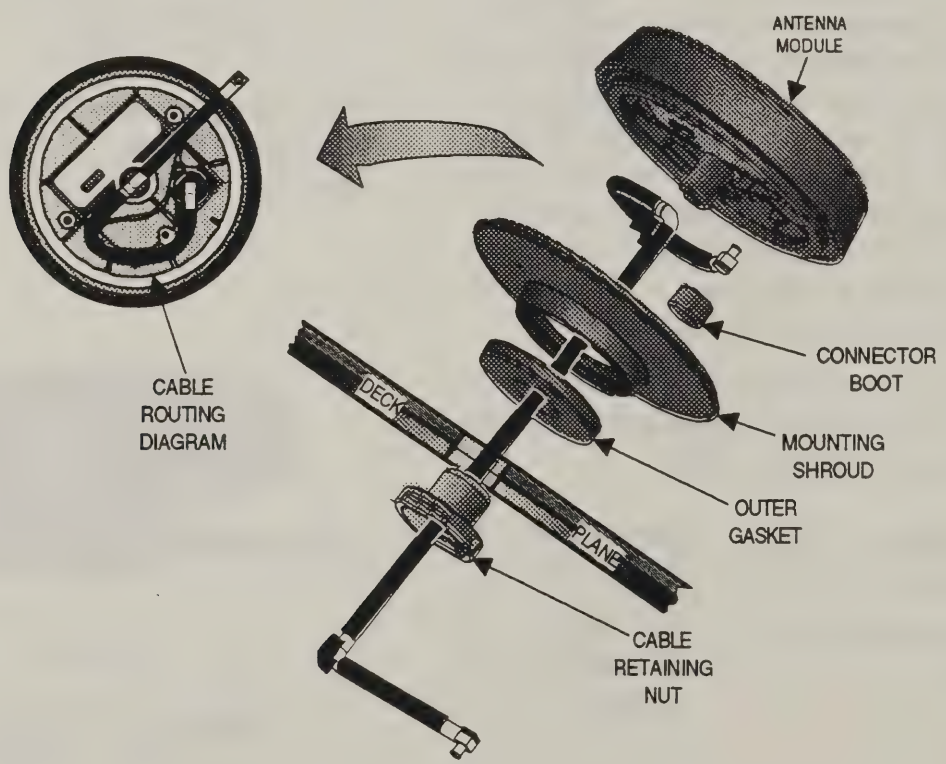


Figure D-2. Direct Mount Kit Assembly

D-3.2 Lip Mount Kit Installation. The Lip Mount (Figure D-3) allows for antenna placement along the edge of a deck plane (3.2 mm maximum thickness), such as the trunk lid of an automobile.

Figure D-3. Lip Mounted Antenna Module

Refer to Figure D-4 and perform the following steps to install the Lip Mount Kit.

1. Insert the Antenna Cable connector to the mating connector at the Antenna Module base.
2. Insert the connector boot over the cable connection and into the circular boot socket.
3. Route the Antenna Cable along the strain relief track located in the bottom of the Antenna Module. (See cable routing diagram.)
4. Fit the mounting shroud to the Antenna Module.
5. Route the Antenna Cable through the side slot in the middle of the mounting shroud base.
6. Place the lip bracket over the threaded stem of the antenna module and pass the cable through the lip bracket cable notch.
7. Tighten the panel nut onto the threaded stem, securing the entire assembly. A 15mm 6 point socket is recommended.
8. Remove peel-off liner from lip bracket pad and adhere pad to the lip bracket covering the panel nut.
9. Clip the lip bracket assembly to the selected antenna deck plane (3.2 mm maximum).
10. Tighten the entire assembly to the deck plane by tightening the set screw. (M5 x 0.8 hex Allen wrench).

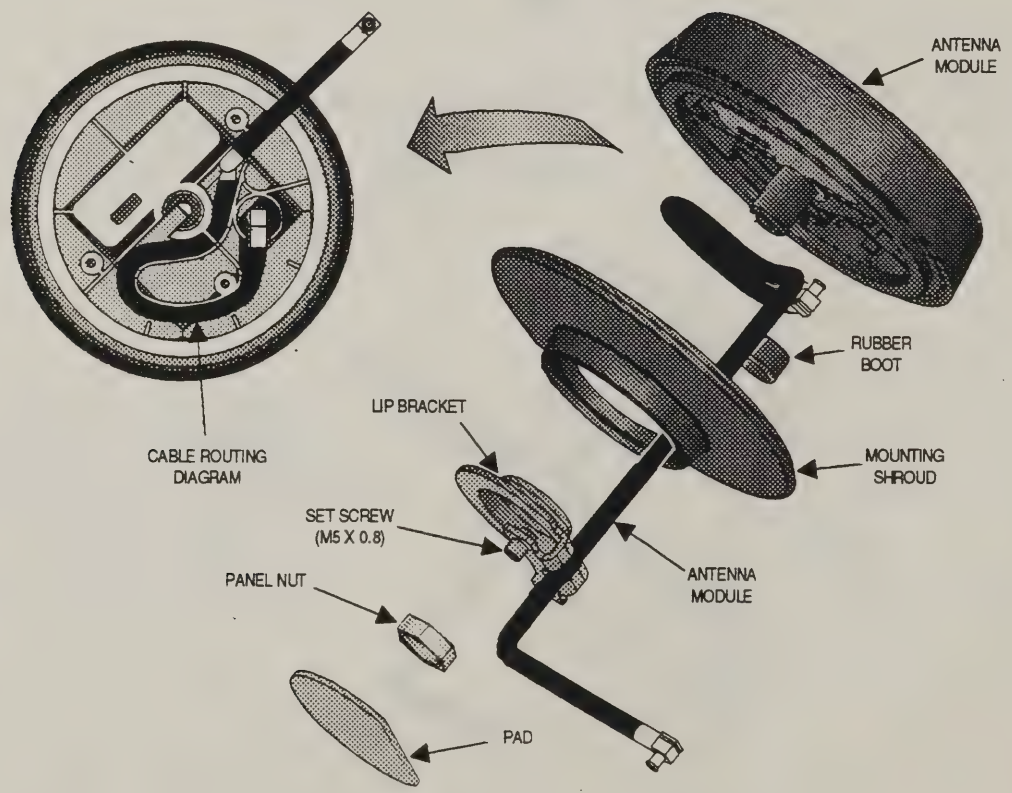


Figure D-4. Lip Mount Kit Assembly

D-3.3 Magnet Mount Kit Installation. The Magnet Mount (Figure D-5) allows you to mount the Antenna Module on a flat metal surface without the need to drill mounting holes.

An adhesive-backed insulator is placed over the magnet at the base of the shroud to prevent surface scratching.

Figure D-5. Magnet Mounted Antenna Module

Refer to Figure D-6 and perform the following steps to assemble the Magnet Mount Kit.

1. Insert the Antenna cable connector to the mating connector at the Antenna Module base.
2. Insert the connector boot over the cable connection and into the circular boot socket. (See cable routing diagram.)
3. Route the Antenna cable along the strain relief track located at the base of the Antenna Module.
4. Insert the Antenna Module into the mounting shroud. Align the shrouds cable exit slot over the cable.
5. Insert the magnet into the shroud such that the magnetic side faces outward.
6. Tighten the panel nut onto the threaded stem, securing the entire assembly.
7. Peel off the adhesive liner from the insulator and adhere the protective insulator over the magnetic surface at the base of the shroud.

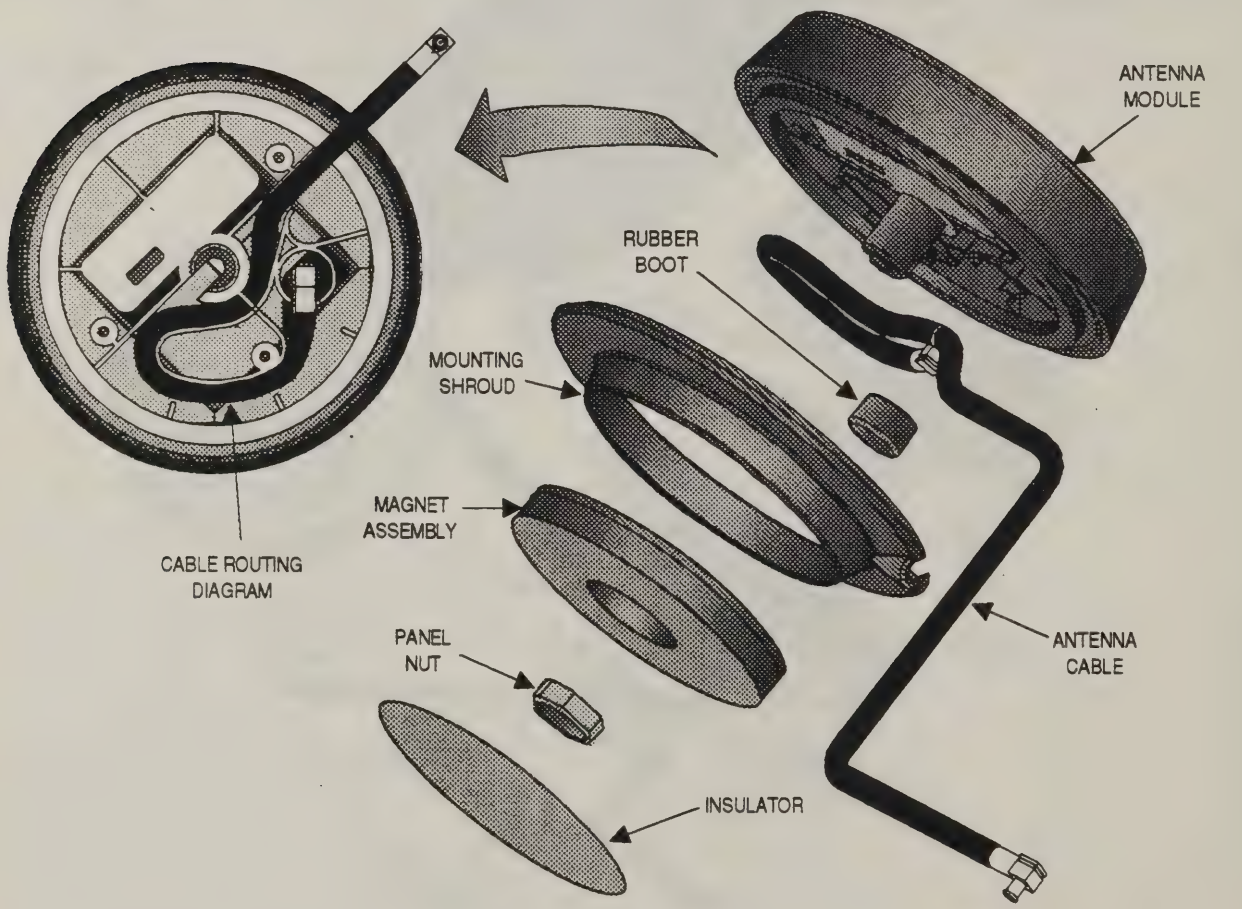


Figure D-6. Magnet Mount Kit Assembly

D-3.4 Post Mount Kit Installation. The Post Mount (Figure D-7) allows you to mount the Antenna Module onto a vertical or horizontal post or bar with a maximum diameter of 30 mm (such as the support arm of a truck's external side mirror).

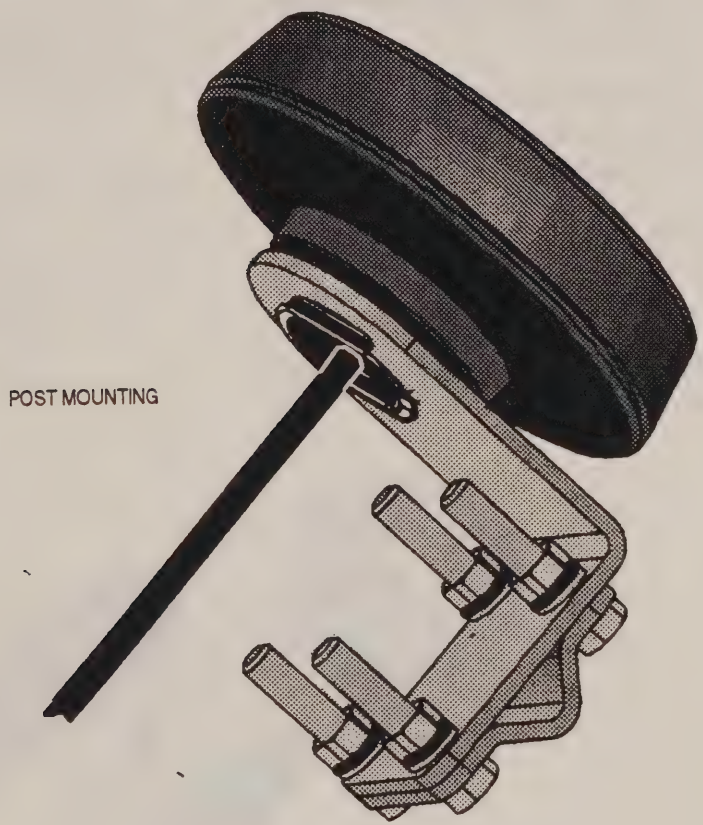


Figure D-7. Post Mount Antenna Module

Refer to Figure D-8 and perform the following steps to assemble the Post Mount Kit.

1. Insert the Antenna cable connector to the mating connector on the Antenna Module.
2. Insert the connector boot over the Antenna cable connector and into the circular boot socket.
3. Route the Antenna cable along the strain relief track located in the base of the Antenna Module.
4. Route the Antenna cable through the hollow slot in the Antenna Module's threaded stem.
5. Remove peel-off liner from the outer gasket and attach to the bottom to the shroud.
6. Insert the threaded stem through the mounting shroud, outer gasket, and post bracket.
7. Install and tighten the cable retaining nut to the threaded stem of the Antenna Module.
8. Attach the post to the post bracket with the bolts, post clamp, lock washers, and nuts.

NOTE: The post bracket can support a vertical or horizontal post by rotating the post clamp. For low profile mounting, route the cable through the side slot in the cable retaining nut.

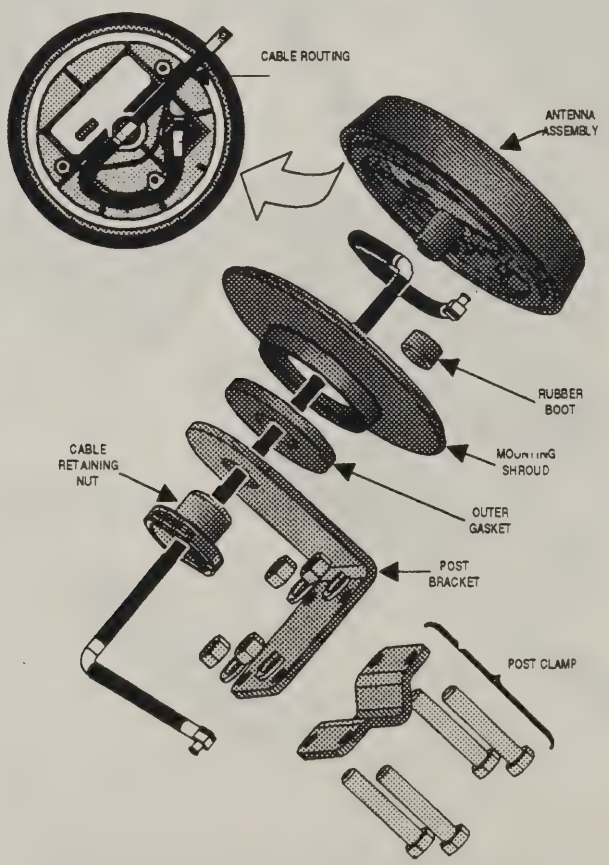


Figure D-8. Post Mount Kit Assembly

D-4 GPS ANTENNA MECHANICAL INFORMATION

The following figures provide you with mechanical dimensions of the GPS antenna components.

NOTE:

1. MATERIAL CHARACTERISTICS:
   1.1 MILES INC., MAKROBLEND OR APPROVED EQUIVALENT.
   1.2 WALL THICKNESS 2.5 MM CONSTANT EXCEPT AS SHOWN OR NOTED.
   1.3 FINISH: MOLD-TECH #MT-11020, SURFACE "A" ONLY. APPEARANCE TO BE CLASS "A" PER SPEC. 12S10782A.

2. TOLERANCES (UNLESS OTHERWISE SPECIFIED):
   2.1 ALL DRAFT ANGLES SHALL BE 1°.
   A DIMENSION FOLLOWED BY THE NOTATION '-1°/S' SPECIFIES THAT THE DIMENSION DECREASES WITH 1 DEGREE OF DRAFT PER SIDE.
   A DIMENSION FOLLOWED BY THE NOTATION '+1°/S' SPECIFIES THAT THE DIMENSION INCREASES WITH 1 DEGREE OF DRAFT PER SIDE.
   2.2 ALL FILLETS AND RADII SHALL BE 0.5 R.
   2.3 A 'REF' (REFERENCE) DIMENSION IS FOR INFORMATION PURPOSES AND HAS NO TOLERANCE IMPLIED.

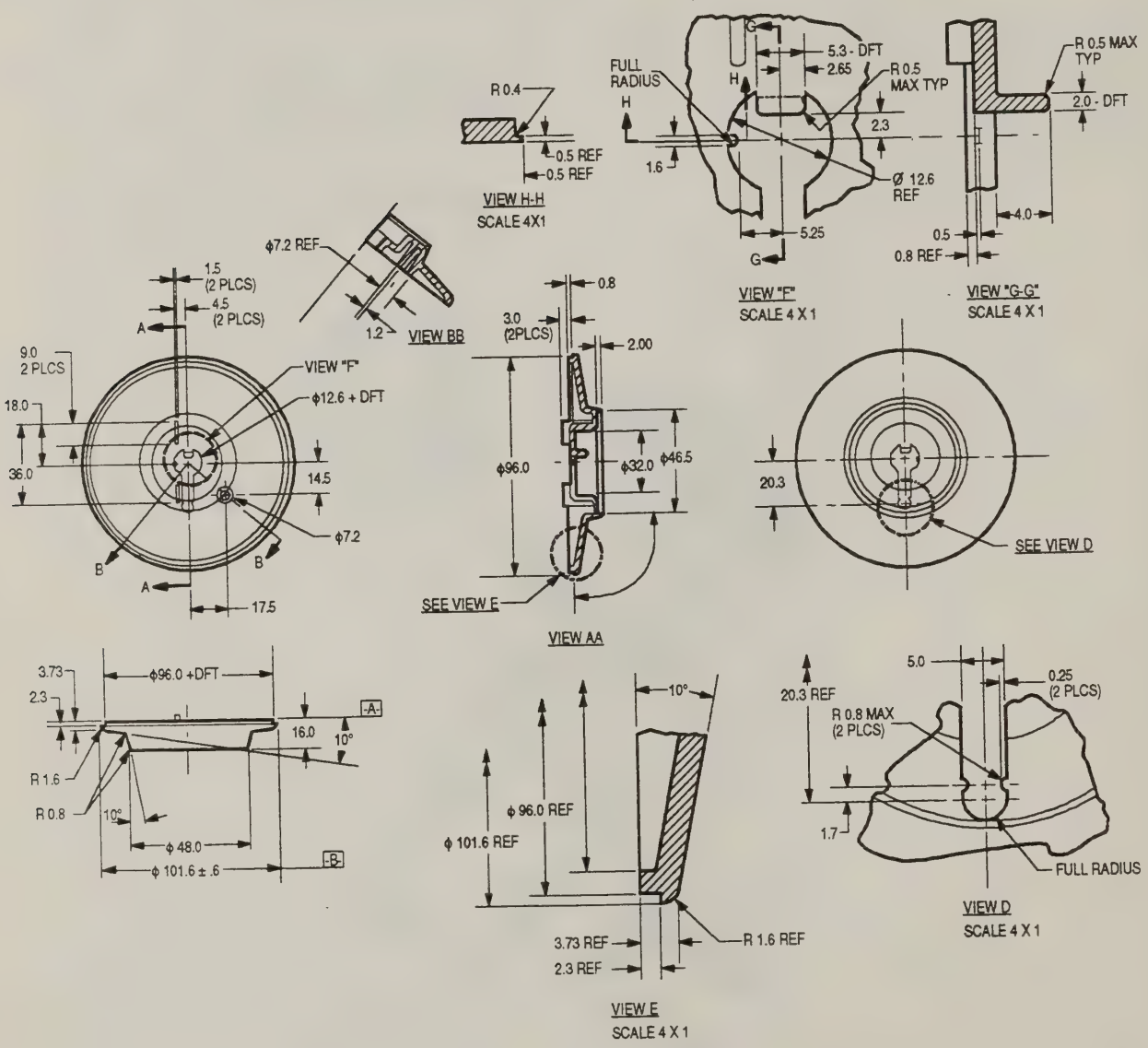


Figure D-9. Mounting Shroud

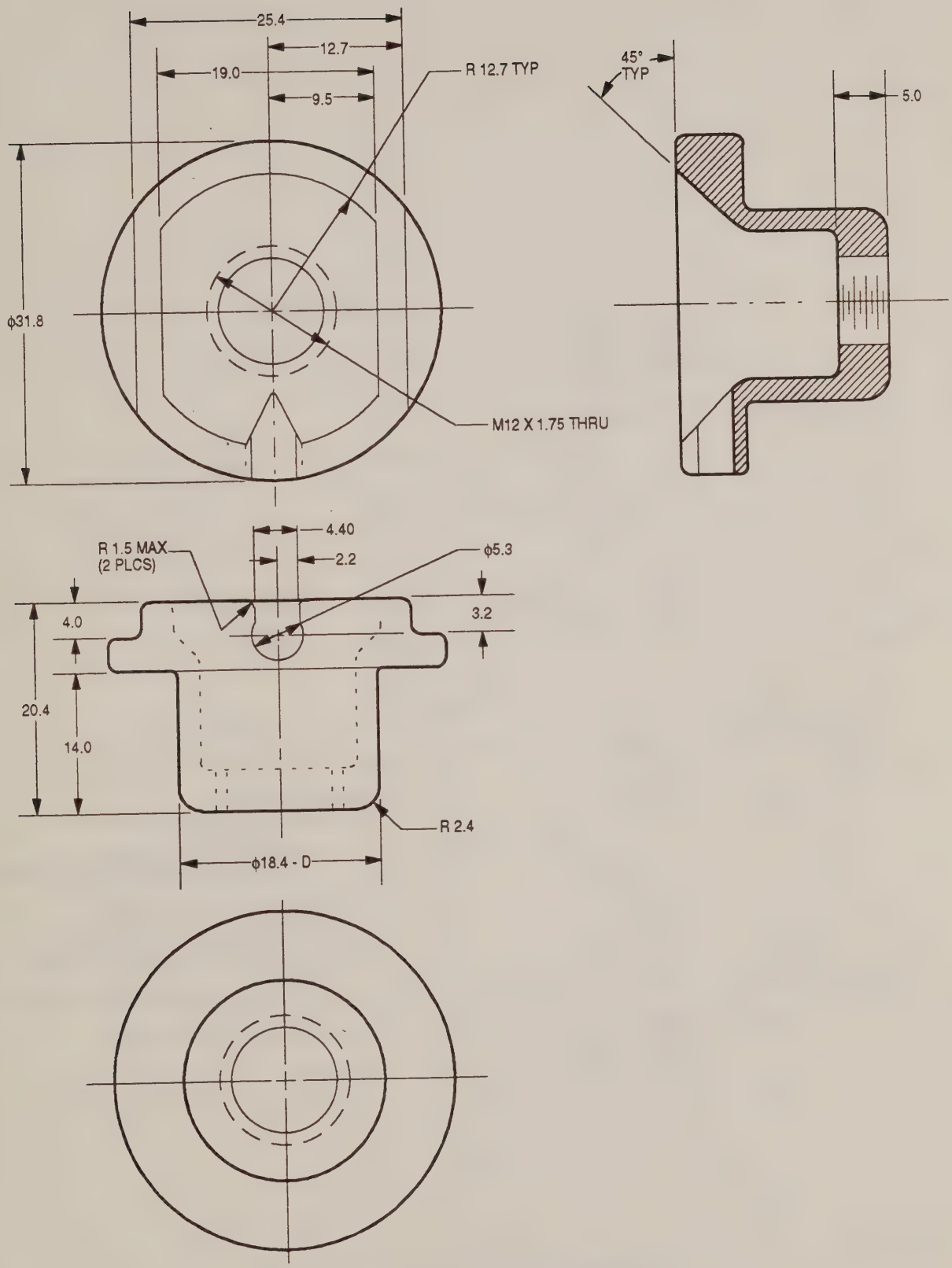
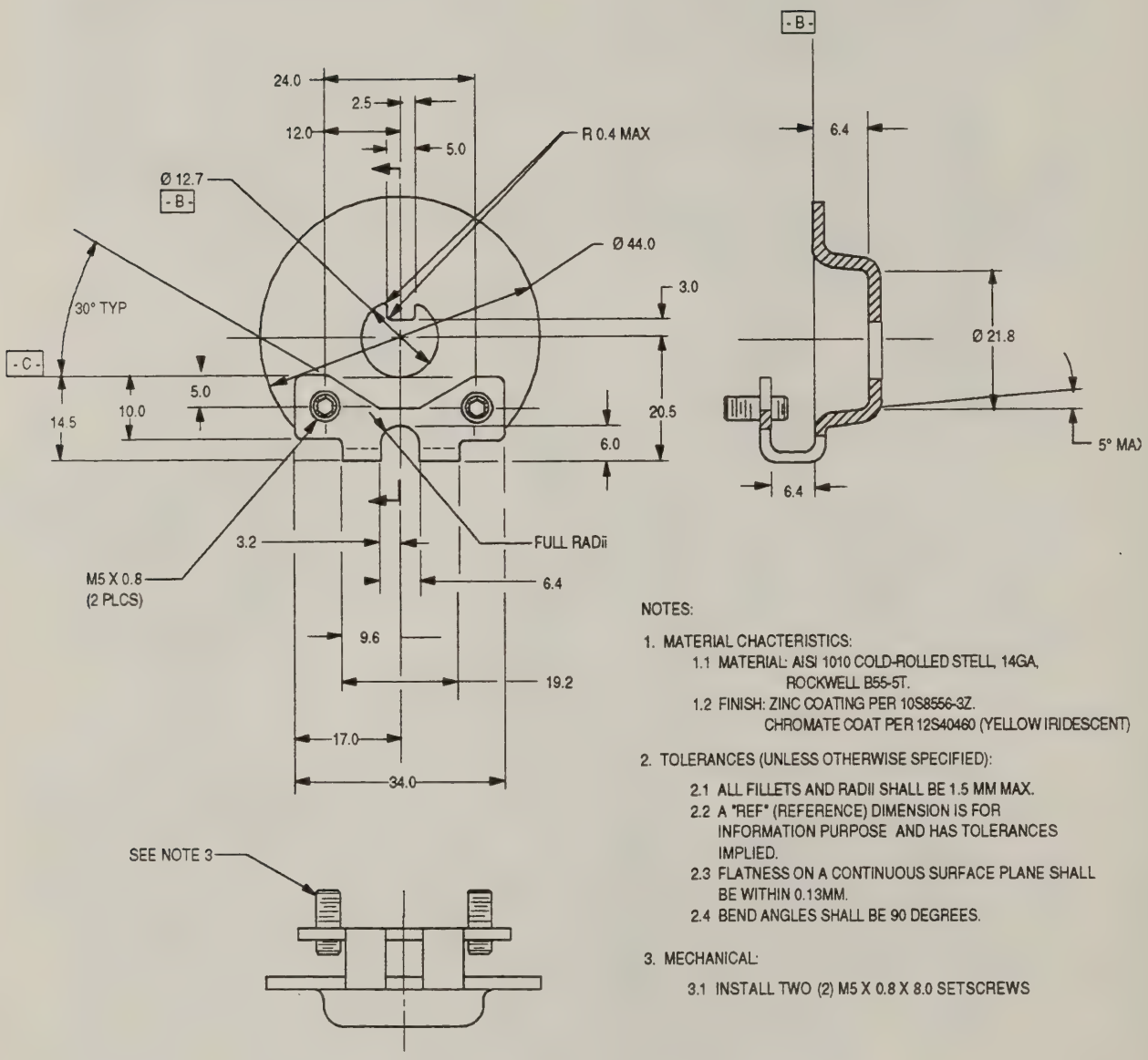


Figure D-10. Cable Retaining Nut



NOTES:

1. MATERIAL CHACTERISTICS:
   - 1.1 MATERIAL: AISI 1010 COLD-ROLLED STELL, 14GA, ROCKWELL B55-5T.
   - 1.2 FINISH: ZINC COATING PER 10S8556-3Z. CHROMATE COAT PER 12S40460 (YELLOW IRIDESCENT)
2. TOLERANCES (UNLESS OTHERWISE SPECIFIED):
   - 2.1 ALL FILLETS AND RADII SHALL BE 1.5 MM MAX.
   - 2.2 A "REF" (REFERENCE) DIMENSION IS FOR INFORMATION PURPOSE AND HAS TOLERANCES IMPLIED.
   - 2.3 FLATNESS ON A CONTINUOUS SURFACE PLANE SHALL BE WITHIN 0.13MM.
   - 2.4 BEND ANGLES SHALL BE 90 DEGREES.
3. MECHANICAL:
   - 3.1 INSTALL TWO (2) M5 X 0.8 X 8.0 SETSCREWS

Figure D-11. Lip Mount Bracket

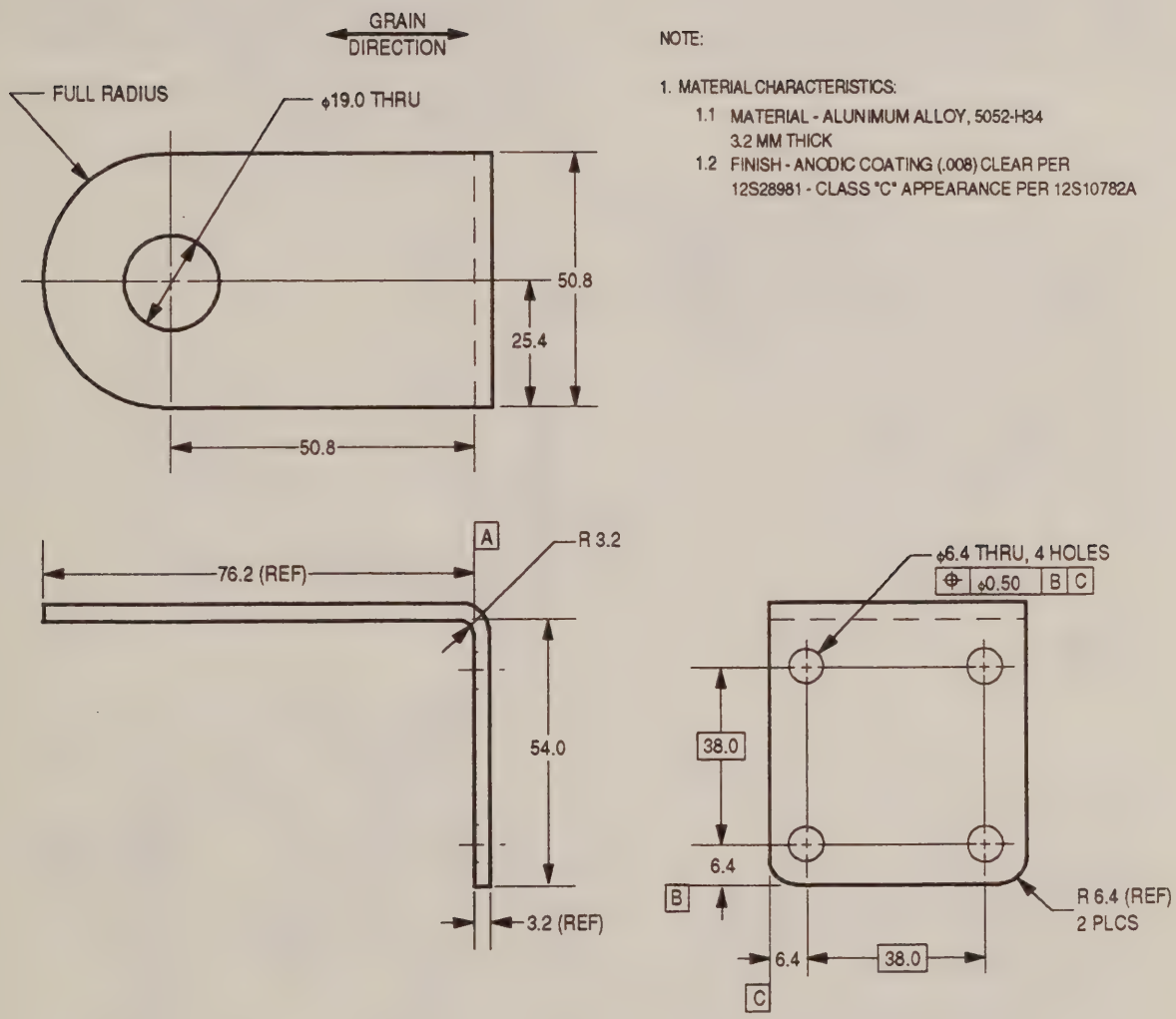


Figure D-12. Post Bracket

NOTE:

1. MATERIAL CHARACTERISTICS:
   1.1 MILES INC., MAKROBLEND OR APPROVED EQUIVALENT.
   1.2 WALL THICKNESS 2.5 MM CONSTANT EXCEPT AS SHOWN OR NOTED.
   1.3 FINISH: MOLD-TECH #MT-11020, SURFACE "A" ONLY. APPEARANCE TO BE CLASS "A" PER SPEC. 12S10782A.

2. TOLERANCES (UNLESS OTHERWISE SPECIFIED):
   2.1 ALL DRAFT ANGLES SHALL BE 1°.
   A DIMENSION FOLLOWED BY THE NOTATION '-1°/S' SPECIFIES THAT THE DIMENSION DECREASES WITH 1 DEGREE OF DRAFT PER SIDE. A DIMENSION FOLLOWED BY THE NOTATION '+1°/S' SPECIFIES THAT THE DIMENSION INCREASES WITH 1 DEGREE OF DRAFT PER SIDE.
   2.2 ALL FILLETS AND RADII SHALL BE 0.5 R.
   2.3 A 'REF' (REFERENCE) DIMENSION IS FOR INFORMATION PURPOSES AND HAS NO TOLERANCE IMPLIED.

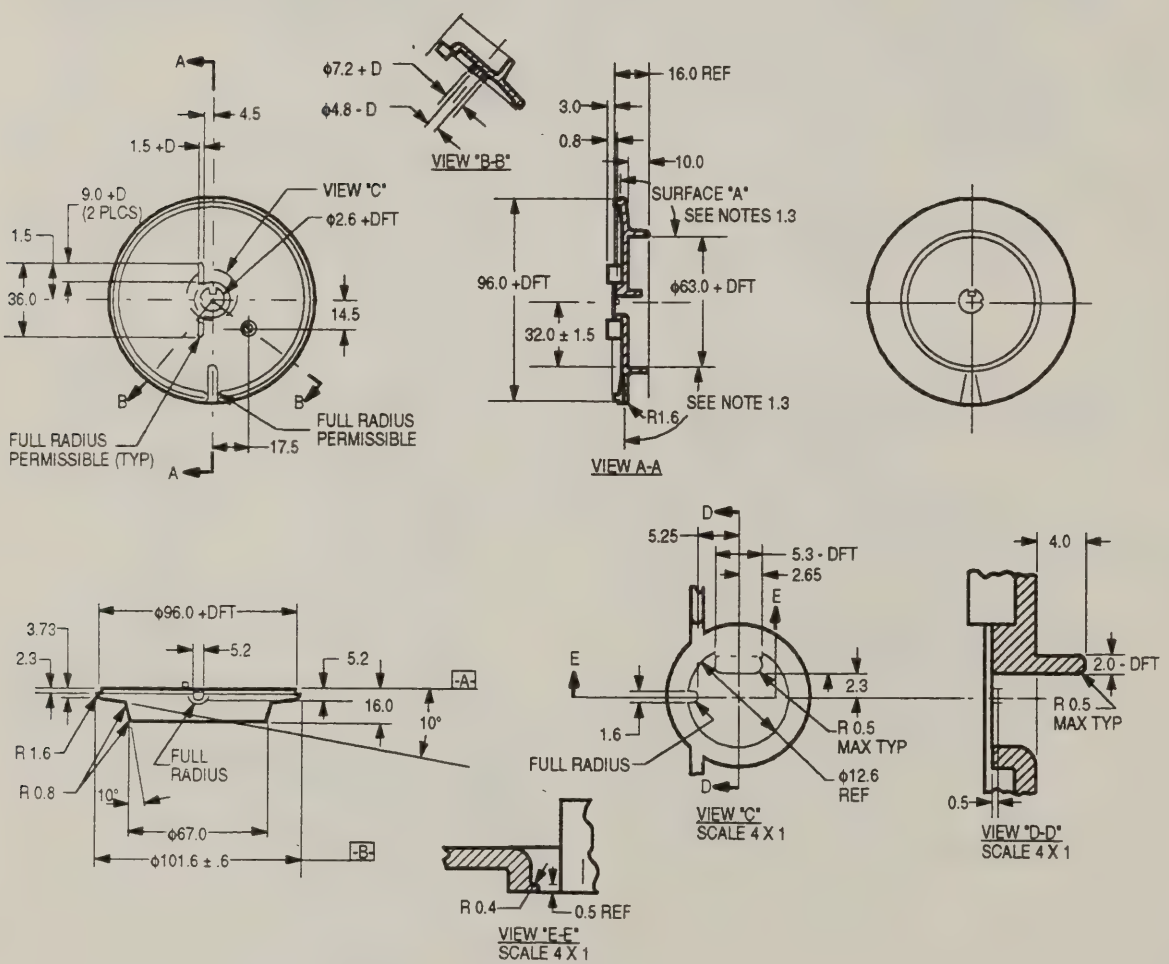
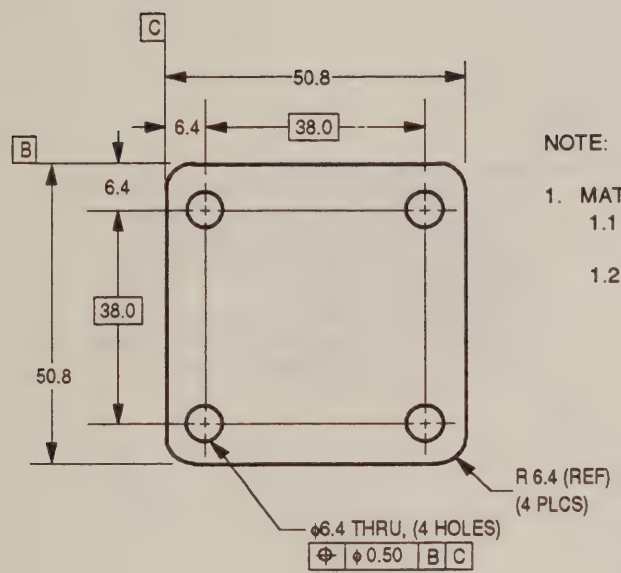


Figure D-13. Magnet Shroud



NOTE:

1. MATERIAL CHARACTERISTICS:
   1.1 MATERIAL - ALUMINUM ALLOY, 5052-H34, 3.2 MM THICK
   1.2 FINISH - ANODIC COATING (0.0008) CLEAR PER 12S28981 - CLASS "C" APPEARANCE PER 12S10782A.

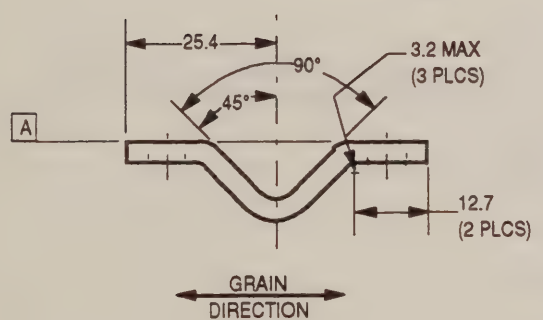
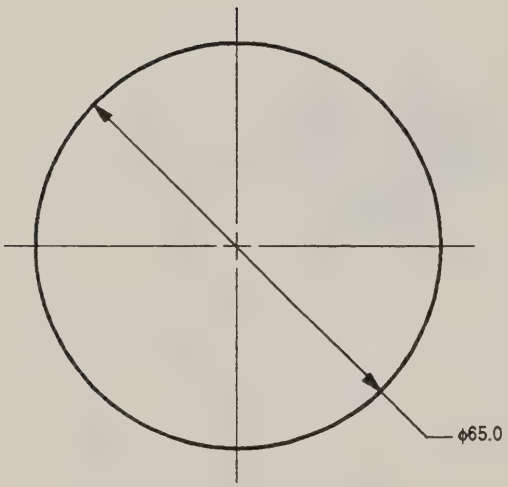


Figure D-14. Post Clamp



NOTE:

1. MATERIAL CHARACTERISTICS:
   1.1 POLYETHYLENE TEREPHTHALATE (0.025 THICK MYLAR), CLEAR, WITH ACRYLIC PRESSURE SENSITIVE ADHESIVE, (ONE SIDE) ON A MOISTURE RESISTANT PAPER LINER OR APPROVED EQUIVALENT.
   1.2 TEMPERATURE RANGE: -40°C TO + 125°C
   SHELF LIFE: 24 MONTHS @ 21°C AND 50% RELATIVE HUMIDITY

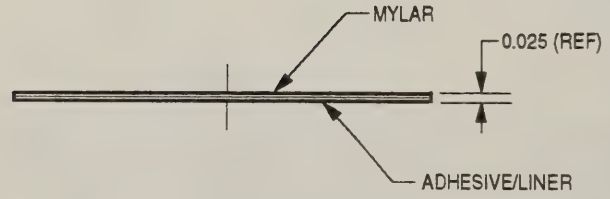
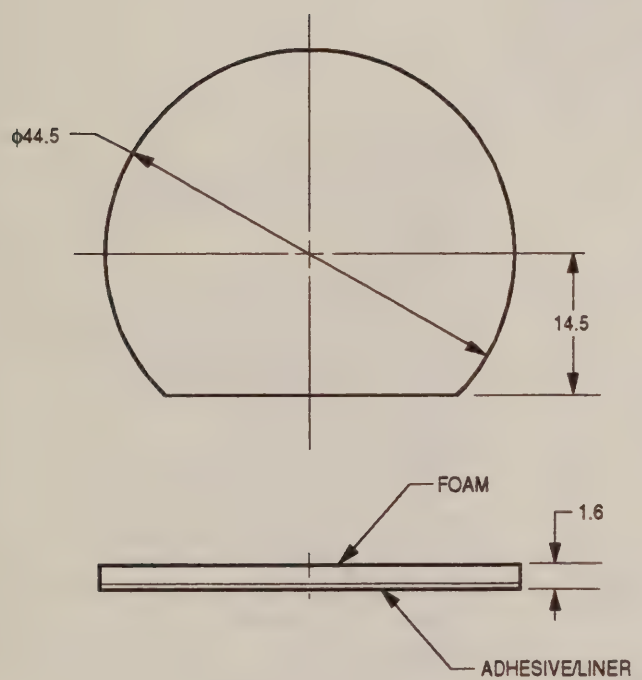


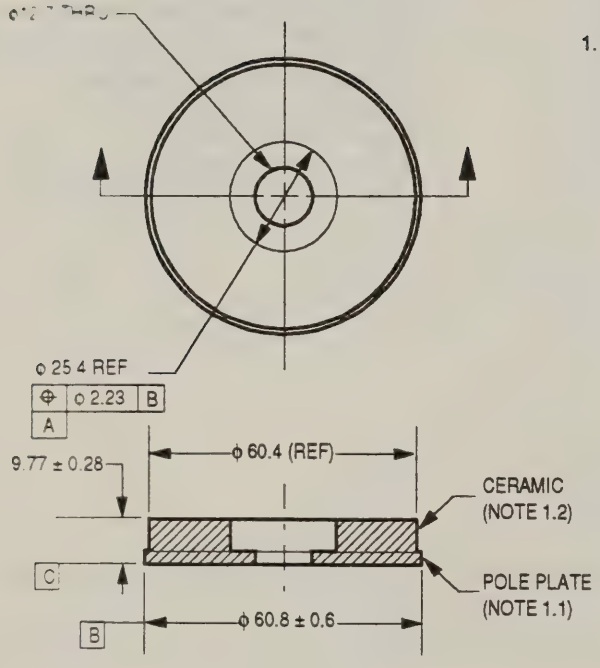
Figure D-15. Insulator



NOTE:

1. MATERIAL CHARACTERISTICS:
   1.1 EPICHLOROHYDRIN FOAM, BLACK IN COLOR, WITH ACRYLIC PRESSURE SENSITIVE ADHESIVE, (ONE SIDE) ON A MOISTURE RESISTANT PAPER LINER OR APPROVED EQUIVALENT.
   1.2 TEMPERATURE RANGE: -40°C TO + 149°C
   FOAM DENSITY: 20-35 PCF
   FOAM COMPRESSION DEFLECTION: 17-24 PSI
   SHELF LIFE: 24 MONTHS @ 21°C AND 50% RELATIVE HUMIDITY

Figure D-16. Lip Bracket Pad



NOTE:

1. MATERIAL CHARACTERISTICS:
   - 1.1 POLE PLATE,
     COLD ROLLED STEEL 12 GA, (2.64)
     ELECTRO-ZINC PLATE PER MOTOROLA SPEC.
     10S8556-5Z
   - 1.2 CERAMIC,
     MMPA CERAMIC #5 ($MO.Fe_2O_3$).
   - 1.3 CERAMIC AND POLE PLATE TO BE PERMANENTLY BONDED TOGETHER AND MUST WITHSTAND -40°C TO +100°C, AND 95% HUMIDITY WITHOUT SEPARTATION OR DEGRADATION OF BOND STRENGTH.
   - 1.4 BONDED ASSEMBLY-
     MAGNETIZATION; 6 POLE -1 FACE
     PULL FORCE; 20 LBS ±5 LBS (STRAIGHT UPWARD VERTICAL PULL)
   - 1.5 PARTS TO BE CLEAN AND FREE OF ALL FOREIGN MATERIAL.
   - 1.6 ALL HOLES AND EDGES OF POLE PLATE MUST BE FREE OF ALL BURRS.
   - 1.7 BONDING MATERIAL:
     METHACRYLATE TWO COMPONENT REACTIVE ADHESIVE, H.B. FULLER #RA-0018 OR APPROVED EQUIVALENT.

Figure D-17. Magnet

NOTES:

1. MATERIAL CHARACTERISTICS:
   1.1 NYLON 6/6, BLACK IN COLOR.

2. TOLERANCES (UNLESS OTHERWISE SPECIFIED):
   2.1 ALL DRAFT ANGLES SHALL BE 1°.
   A DIMENSION FOLLOWED BY THE NOTATION ' - 1° /S ' SPECIFIES THAT THE DIMENSION DECREASES WITH 1 DEGREE OF DRAFT PER SIDE. A DIMENSION FOLLOWED BY THE NOTATION ' + 1° /S ' SPECIFIES THAT THE DIMENSION INCREASES WITH 1 DEGREE OF DRAFT PER SIDE.
   2.2 ALL FILLETS AND RADII SHALL BE 0.5 R MAX.
   2.3 A 'REF' (REFERENCE) DIMENSION IS FOR INFORMATION PURPOSES AND HAS NO TOLERANCE IMPLIED.

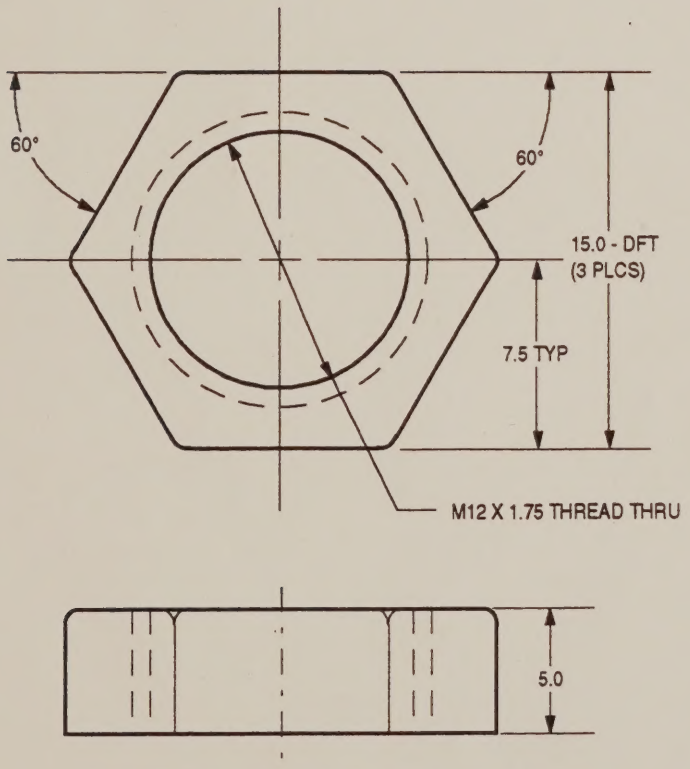
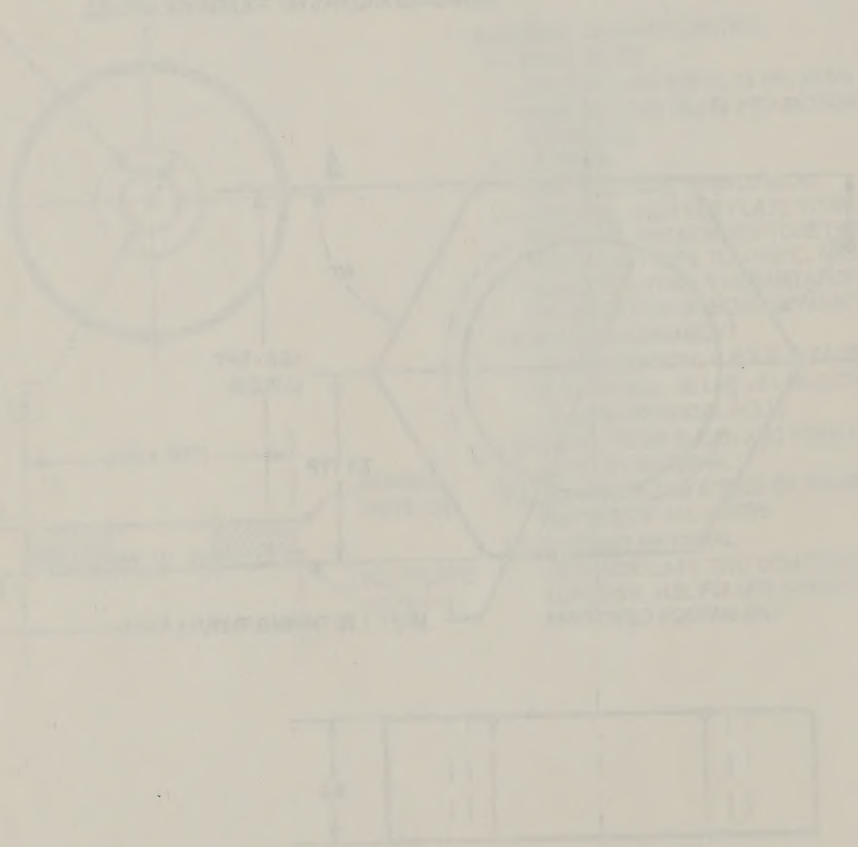
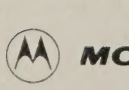


Figure D-18. Panel Nut





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